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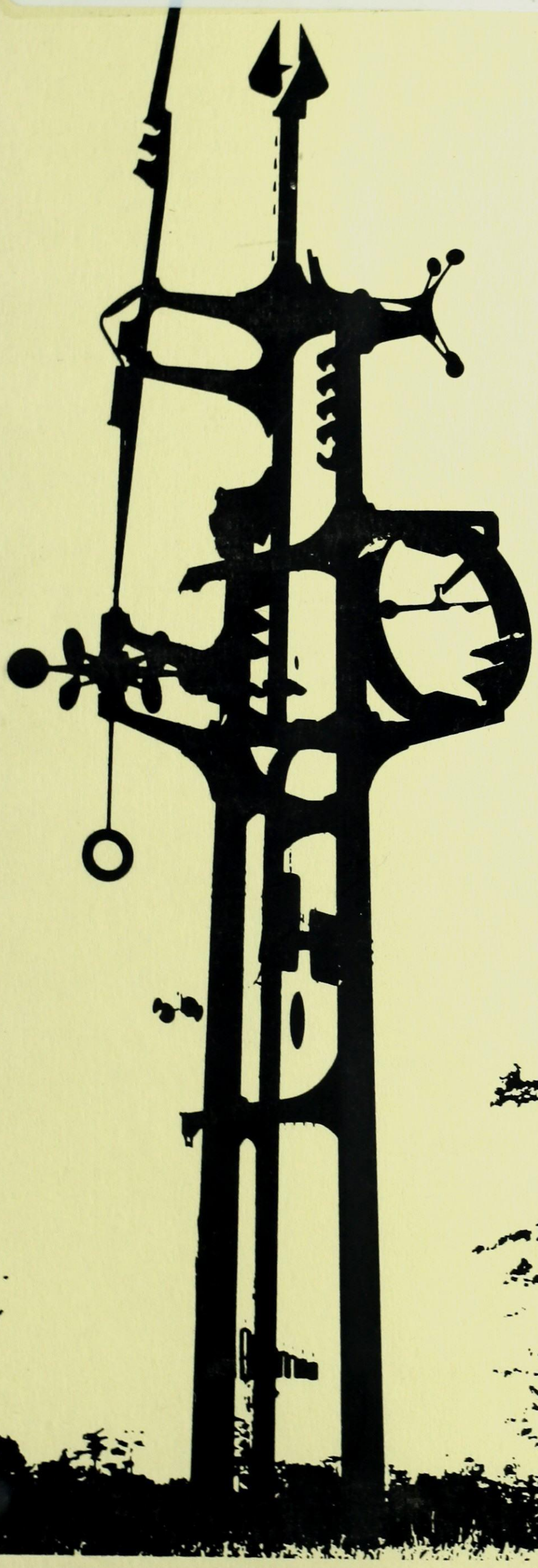


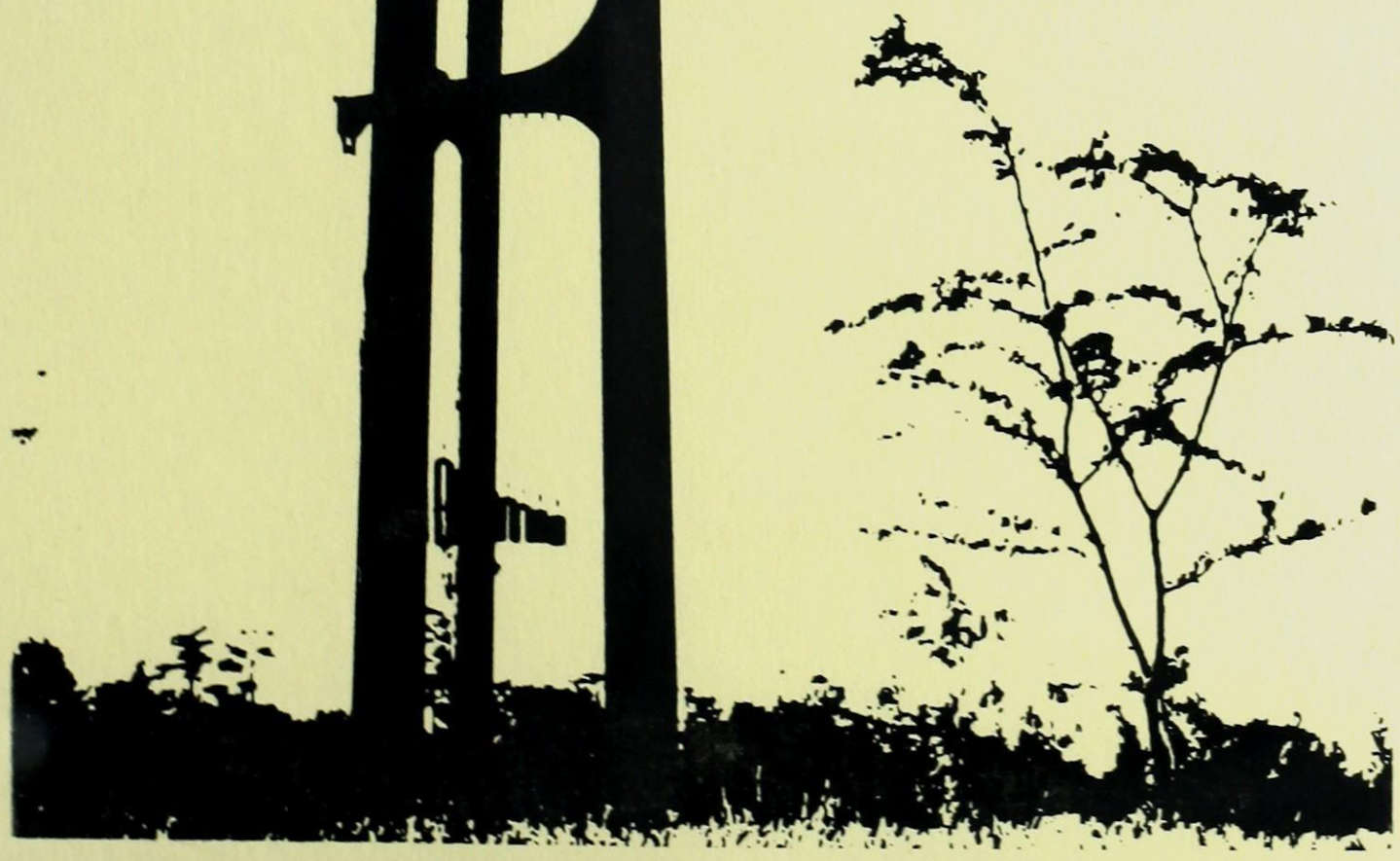
Air Quality and Inter-Environmental Research Branch

Annual Report

1987-88

Environment Canada / Environnement Canada

Atmospheric Environment Service / Service de l'environnement atmosphérique



REPORT: AQRB-88-M-001

AIR QUALITY AND INTER-ENVIRONMENTAL RESEARCH BRANCH

ANNUAL REPORT

1987-88

Compiled by

J. Padro

Cover Photograph by

N.B.A. Trivett

May 1988

This is one of a series of management reports produced by the Research Directorate. It is intended for internal use only.

Air Quality and Inter-Environmental Research Branch
Atmospheric Environment Service
4905 Dufferin Street
Downsview, Ontario, Canada M3H 5T4

Our Resident Cartoonist

In previous annual reports we derived much pleasure from cartoons drawn by Fouad Fanaki. This year, due to illness, Fouad was unable to make his usual contribution. We hope that the replacement cartoons by his friend, Bill Johnson, will bring some mirth to our friend and colleague and encourage him toward a speedy recovery.

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Foreword

by: James W.S. Young, Director

Air Quality & Inter-Environmental Research Branch (AQRB)

The Air Quality and Inter-Environmental Research Branch was formed in the early 1970's to deal with a series of pollution and inter-environmental problems that were being recognized as having an atmospheric component. Essentially the structure that was established at that time is in place today - a dispersion division, a chemistry division, a boundary layer division and a monitoring and assessment division.

By early 1985 I recognized that, with the trend to less resources, the Branch would have to become much more focussed on priorities and work together as one unit (not as a collection of divisions). The long time in a stable configuration had led to some barriers in the minds of many staff so that true Branch integration would be impossible without a change.

The re-organized AQRB (effective implementation on April 1, 1988) will be characterized as what Robert C. Ernest* calls an "integrated corporate culture". Corporate cultures are characterized by two dimensions - action and people. The "action" dimension can range from reactive to proactive while the "people" dimension ranges from non-participative to participative. The "AQRB integrated culture" will have a strong people orientation (participative) combined with effective identification of problems and opportunities (proactive).

The AQRB must understand the atmospheric chemical and physical environment as it relates to environmental (air) quality and provide information for sound environmental policy decisions.

We will do this by making **measurements** (to ascertain the extent and quality of atmospheric chemicals), by studying **processes** (to understand the method of operation), through **integration** (combining parts into a whole) and through the provision of air quality **services**.

Specifically, the AQRB must:

Measurements : Be able to state what changes have occurred (or will occur) in the concentration or deposition of tropospheric chemicals at selected sites representative of the diverse natural or man-made surfaces in Canada.

Processes : Be able to characterize the chemical and physical fluxes of tropospheric chemicals to and from the diverse natural or man-made surfaces representative of the regions of Canada.

---

* "Corporate Cultures and Effective Planning" by Robert C. Ernest, Personnel Administrator, March 1985.

Integration : Be able to combine into a whole understanding, the chemical and physical aspects of the troposphere and its interaction with the diverse natural and man-made environment of Canada.

Services : Have the capability to provide, through the AES regional centres, information and advice on atmospheric (air) quality that might endanger the safety and security of Canadians during environmental emergency situations or as a result of economic development activities.

The new structure will focus on the generic form of problems and their solution and the need for measuring, understanding processes, integrating into the bigger picture and the separate role of providing services with the new knowledge.

This new structure should provide a better focus on issues and allow us to effectively deliver the AES Air Quality Strategic Plan 1987-2007.

3. AQRB Programs for 1987-88

3.1 ACID RAIN (LONG RANGE TRANSPORT OF AIR POLLUTANT PROGRAM - LRTAP)

3.1.1 Program Management, Liaison and Co-ordination

The Air Quality Branch manages the atmospheric component of the federal Long Range Transport of Air Pollutants. Participation in the Federal/Provincial LRTAP/Acid Rain Monitoring and Research Committee (RMCC) and the Interdepartmental LRTAP committees and their associated sub-committees assists in the co-ordination of the AES program. M.L. Phillips represented AES and was the federal co-chairman of the atmospheric sciences sub-group of RMCC; K.J. Puckett was the AES representative on the ILC science subcommittee.

A major activity was the planning and co-ordination of the joint U.S.-Canada Eulerian model evaluation project and its associated field study. AES was represented on the Eulerian Model Bilateral Steering Committee by J.W.S. Young and on the Project Management Group by K.J. Puckett.

Contact: K.J. Puckett

3.1.2 Eulerian Model Development

The Acid Deposition and Oxidants Model (ADOM) is an Inter-Agency Eulerian LRTAP modelling project funded jointly by the Ontario Ministry of the Environment (OME), the Atmospheric Environment Service (AES) the Umweltbundesamt (UBA) of the Federal Republic of Germany, and the Electrical Power Research Institute (EPRI) of the U.S.

The main model development has been done by Environmental Research and Technology, Inc. (ERT).

Recently, a standardized master version of the model code has been established by the implementation of the CDC UPDATE facility. ERT is currently upgrading the model code with UPDATE to a version which is known as ADOM2. This includes a revised gas phase chemistry and a new aerosol chemistry. The cumulus cloud module is recognized to be the weakest part of ADOM, and ERT has been researching two alternative upgrades.

In North America, the emissions and meteorological data bases needed to drive ADOM are being assembled by Meteorological and Environmental Planning Ltd. (MEP). The emissions data base currently being used was generated from the final version of the NAPAP 1980 emissions inventory. Subsequent emissions data bases will be generated from the NAPAP 1985 emissions inventory when this becomes available.

The evaluation of ADOM has proceeded in two phases. In the preliminary evaluation phase, work so far has focused on two historical periods for which a limited number of special air quality observations are available. These are the OSCAR period of April 10-29th, 1981 and the PEPE/NEROS period of August 7-12th, 1980. To complete the preliminary

evaluation phase, ADOM has been integrated for seven episodes of high acidic deposition, which range in length from 4 days to 11 days, and also for the first 47 days of the ANATEX experiment of 1987. The main evaluation of ADOM will be based on the air quality observations taken during the Eulerian Model Evaluation Field Study (EMEFS). This will commence in June 1988 and include three or four intensive periods of up to two months in duration. Concurrently, the U.S. is undertaking a parallel evaluation exercise with the similar RADM model developed at NCAR/SUNY.

Contact: D. Davies

3.1.3 Lagrangian Model

The sulphur Lagrangian model was run for the LRTAP Liaison Office, AES (LLO) to estimate transboundary fluxes and deposition to New Brunswick and Nova Scotia using several emissions scenarios. The model was also used to estimate the changes in transboundary fluxes for eastern Canada due to interannual meteorological and emissions variability. The Arctic version of the model was redesigned to use 25-day back trajectories to compute the sulphur concentration at several Arctic sites during 1980. Parameter sets for inside and outside the Arctic circle gave improved results showing maximum Eurasian input to the Arctic and maximum sulphur concentrations at Arctic sites in the spring.

The model coefficients were modified as a result of the International Sulfur Deposition Model Evaluation project (ISDME) and model results for 1980 were submitted for reevaluation using the ISDME criteria. Some improvements were evidenced in the wet deposition fields especially in the winter and fall. The ISDME final report was officially released in March. A model comparison was also made with the OSCAR data (April 1981).

The sulphur/nitrogen chemistry model was modified to operate on the CRAY computer and was used to compute concentration and deposition fields over eastern Canada for 1980. Preliminary budget estimates were made, sensitivity studies were conducted and extensive comparisons are being made between model results and observed data where possible.

Contacts: M.P. Olson, E.C. Voldner, K.K. Oikawa

3.1.4 CAPMoN - Canadian Air and Precipitation Monitoring Network

This was a very busy year for the CAPMoN Network. From the installation of new sites to the publication of 1985 and 1986 data and the preparation for the Eulerian Model Evaluation Field Study, the ground work was laid for a very productive 1988.

VERY SIGNIFICANT METEOROLOGICAL EVENT

A new site was installed at Chapais, Quebec, where complete site preparation was undertaken and precipitation chemistry sampling began in November. Preparations continued for a site on Saturna Island, British Columbia. The site at Port Cartier, Quebec, was improved and a site was approved at Snare Rapids, Northwest Territories, where the Territorial Government will operate a station meeting CAPMoN criteria. This type of cooperative arrangement is seen as a very effective way for the Provinces and Territories to operate stations meeting CAPMoN siting and operating criteria. Since the Air Quality Branch (AQRB) shoulders the infrastructure costs, this type of arrangement couples the benefits of a proven operating protocol and of cost sharing for the agencies involved.

As the year progressed, activities escalated in preparation for the Eulerian Model Evaluation Field Study (EMEFS). The CAPMoN network will participate in 1988, along with four other Canadian and American networks, in the evaluation of performance of two Regional Acid Deposition and Oxidants models. EMEFS has provided the impetus for installation of the new air sampling system, complete with data logger to automate and streamline the data collection process. Preparations were also made to install ozone monitors and Belfort precipitation gauges at selected sites within the EMEFS study domain.

Operational development for the CAPMoN Network resulted in two significant improvements. The air filter pack assembly was modified to reduce differential contraction and to facilitate installation and removal. The new filter pack assembly, together with new loading procedures, results in better cold weather performance. A significant cost savings over switching to alternate filter packs was realized, since the new filter packs make use of parts from the previous filter packs. In the precipitation chemistry program, we were able to find and use sample bags which did not interact chemically with the contents. We are optimistic that additional development work on the physical properties of the bag will yield a bag which we can use for the foreseeable future.

1987/88 was also a very rewarding year. The publication of 1985 and 1986 precipitation chemistry data made it possible to begin using a quality controlled, continuous, multi-year data set. The data management tools that have been developed for use with CAPMoN data have made two significant contributions to the CAPMoN program. First, they have provided feedback mechanisms which allow us to examine station and network performance and to identify anomalies which might warrant further investigation. Second, they have provided strong support for the tremendous efforts which were put into quality control/assurance over the past few years. The importance of CAPMoN data is augmented by our confidence in the high quality of the data set.

Contacts: C.S. McNair, R.J. Vet

3.1.5 CAPMoN Chemical Analysis

The chemical analyses required to determine the daily average concentrations of atmospheric particles, nitric acid and sulphur dioxide were continued as part of the operations of the eight site air monitoring network. An additional responsibility undertaken was the analytical support of the Forest Dry Deposition Study. This substantial backlog of samples has almost been eliminated.

The laboratory quality assurance plan for chemical analyses has been expanded to include more extensive routine internal controls. Three external intercomparison studies were completed and these studies indicate that the laboratory is operating in a satisfactory manner.

A pilot project to evaluate the new filters and filterpacks was completed as part of the laboratory's preparatory role in support of the Eulerian Model Evaluation Field Study.

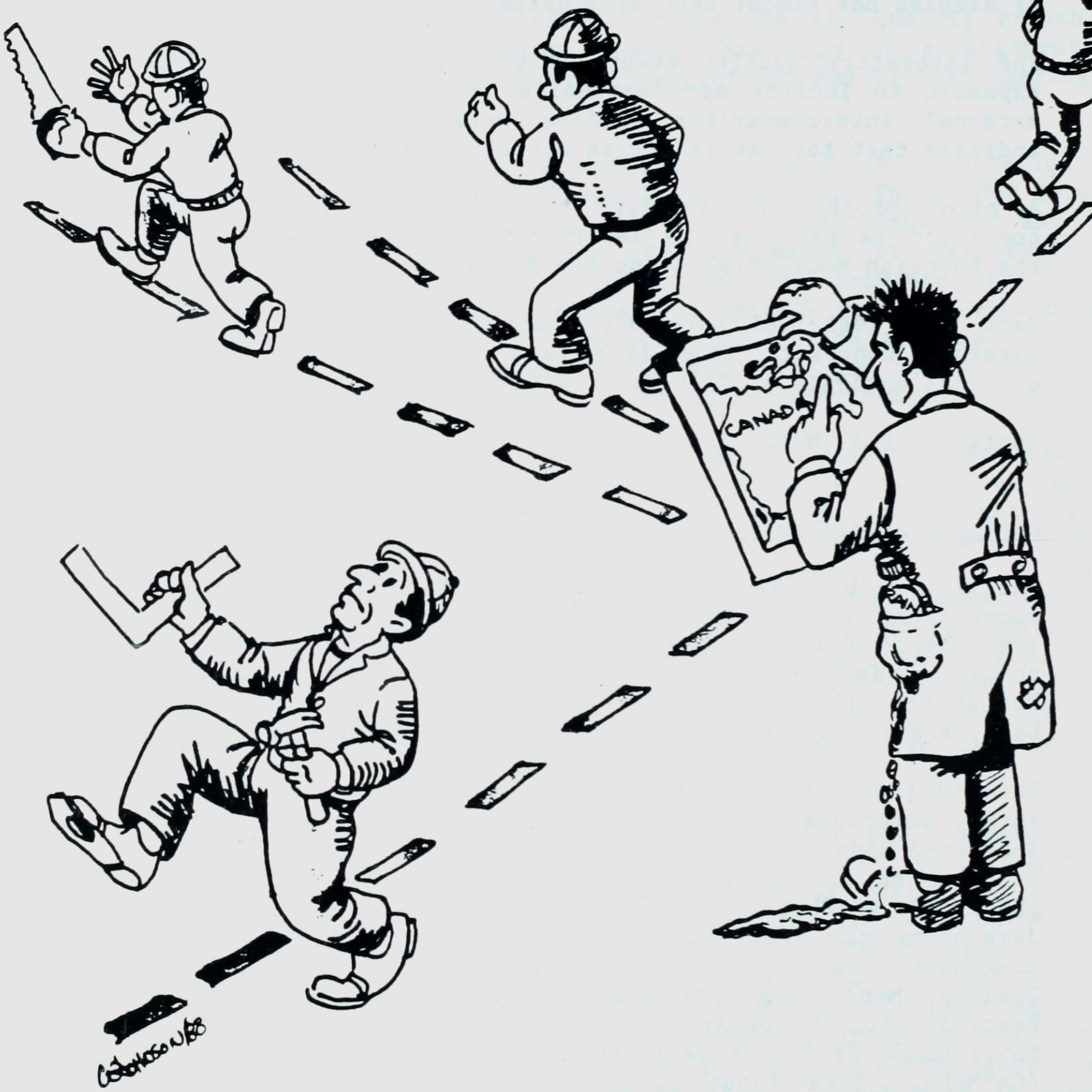
Data from 1983-1985 have been quality controlled and verified under external contract. The 1986 data are currently under review. The chemical analysis of filters collected in 1987 is 90% complete.

Contact: D.A. MacTavish

3.1.6 National Atmospheric Chemistry Data Base (NAtChem)

The NAtChem Data Base System is a facility for archiving, analyzing and summarizing federal and provincial atmospheric chemistry data. The atmospheric data of concern are regional-scale air and precipitation chemistry data from all federal and provincial monitoring networks. The system will consist of three data bases: a network information data base, a site information data base and a chemistry data base.

In this fiscal year, a functional specification document outlining the entire structure and content of the data base system was finalized and delivered under contract. A full time staff member, C.U. Ro, was hired to work on the implementation and operation of NAtChem. The first phase of NAtChem implementation was initiated. It consisted of developing the data base into a working system for 1986 precipitation chemistry data from three pilot networks - the Alberta Precipitation Quality Monitoring Program (PQMP) Network , the Ontario Acidic Precipitation in Ontario Study (APIOS) Network, and the Atmospheric Environment Service's Canadian Air and Precipitation Monitoring Network (CAPMoN). Data input forms for both network and site data base information were developed. In-person contact was made with the two provincial pilot networks and detailed information was requested for the network, site and chemistry data bases.



OK GUYS!! THESE ARE THE NEW CAPMoN SITES... THEY ARE TO BE COMPLETED YESTERDAY.

Finally, a contract was let to develop a spatial interpolation and plotting system based on the interpolation technique known as Kriging. The system will take single- or multiple-network chemistry data, produce a grid of interpolated values, determine isopleths of constant concentration or deposition, and plot the isopleths on a map(s) of Canada and/or North America. The system, known as the NAtCon (National Atmospheric Data Base Contouring) System will be implemented as an option within the Canadian Climate Centre's Contour Analysis System (CONAN). Delivery of the system is targetted for April, 1988.

Contact: R.J. Vet

3.1.7 CAPMoN Data Analysis

A study of the relationship between the mean and standard deviation in precipitation chemistry measurements across eastern North America has been made. It was found that the standard deviation is linearly related to the mean with a slope that decreases when one goes from daily sampling period to weekly or monthly.

A computer program, using simulation techniques, has been developed to estimate the effects of mixing samples on the calculation of the seasonal and annual wet deposition. Preliminary results have been obtained in the case of the monthly, seasonal and annual sulphate wet deposition at sites where daily samples were collected using the 1979-1983 APN data.

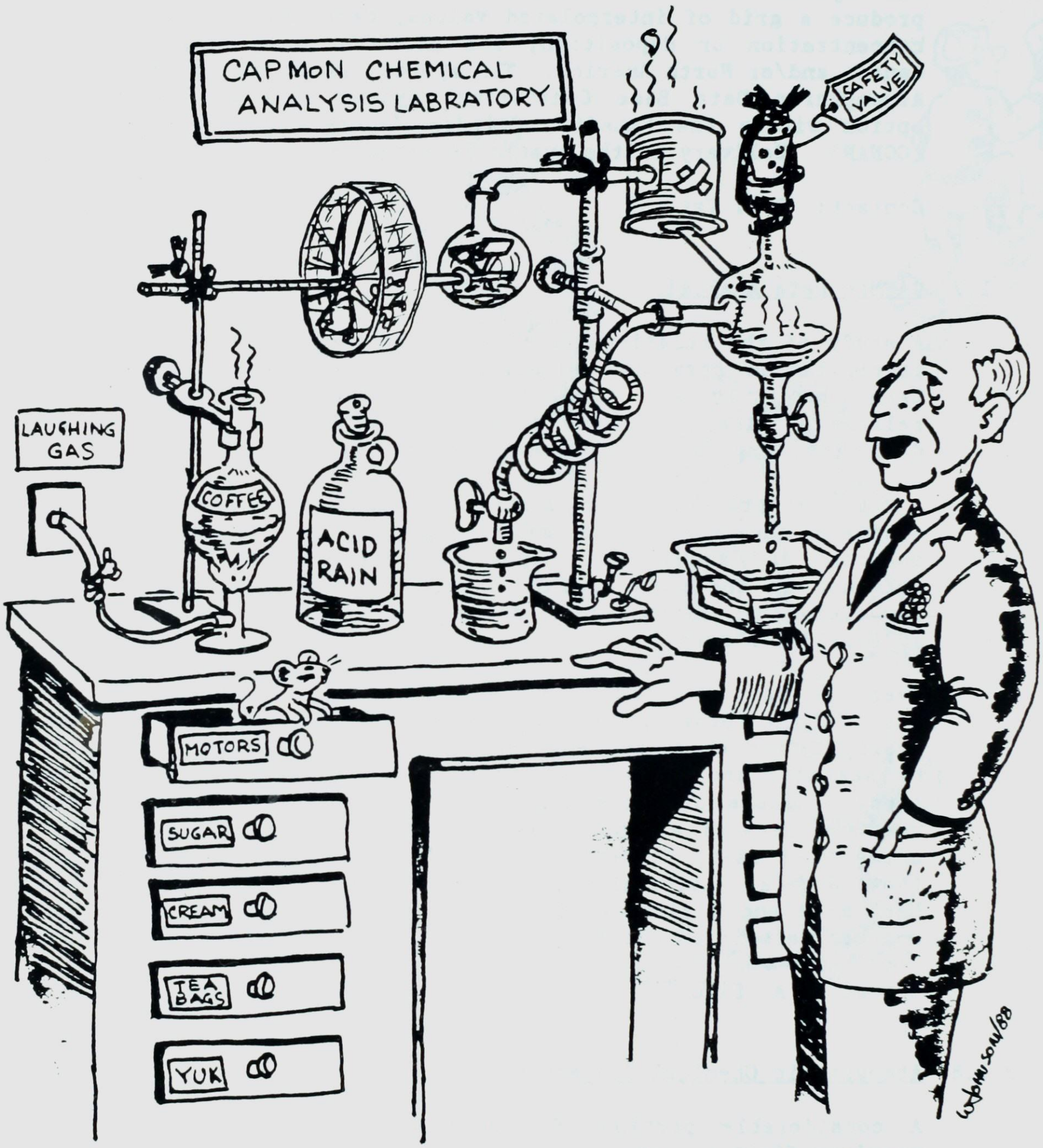
Over the past two years, a special study has been carried out within the CAPMoN program to determine the precision of the daily precipitation chemistry and precipitation depth measurements as well as of seasonal and annual concentration and wet deposition values. The study consists of operating two precipitation chemistry collectors and used two sets of standard gauges concurrently at the same site. Three sites were used, Priceville (Ontario), Sutton (Quebec) and Kejimkujik (Nova Scotia). An analysis of the first year and half of the data have been made and a first estimation of the precision of the concentration and wet deposition obtained by the CAPMoN network has been calculated.

Contact: A. Sirois

3.1.8 Atmospheric Chemical Processes

A considerable portion of time was spent on analysis of data from previous field studies.

Analysis of the Cold Creek field study data has indicated that frequently there are high nighttime aerosol nitrate concentrations which are associated with high NO_2 concentrations. This particulate nitrate formation is thought to be the result of nighttime chemistry, indicating that this activity may be of more significance than previously estimated.



AFTER EXHAUSTIVE ANALYSIS AND PROFOUND CONSIDERATION I THINK I HAVE INVENTED A NEW PERFUME...

An analysis of data on PAN, HNO_3, O_3 and particle nitrate concentrations as measured at several eastern Canadian sites has shown that PAN accounts for a significant fraction of the observed oxidized nitrogen species, and appears to make an increasing contribution as the transport time from the source region increases.

Results from previous intercomparison field studies show that citric acid-impregnated Whatman 41 filters measure gaseous ammonia within about 10% in comparison to other methods. Nitric acid measurements by nylon filters and other techniques have shown that again the filter technique compared well with other more sophisticated techniques.

An ozone analyzer was installed at the Algoma CAPMoN site for the period May 25 to November 18, 1987 and the hourly data were analyzed. It can be concluded from the analysis that for the summer of 1987 occurrences of high ozone concentrations were infrequent and were similar to those measured at the high elevation CHEF sites in Quebec.

The enzymatic-fluorometric NCAR method was used to measure H_2O_2 for several weeks at the Mt. Roundtop, Quebec, CHEF site. Measured concentrations were similar to those measured at Whiteface Mountain, NY (some 173 km to the southwest). Gas phase H_2O_2 was in the range 0.1-1 ppbv and cloud-water aqueous phase H_2O_2 molarity was in the range 1-30μm during the periods August 9-17 and September 2-8, 1987.

This field study showed that the method is not yet readily amenable to routine measurements without a full-time operator and good laboratory back-up. Laboratory studies are presently underway to further test the stability of the system and adapt it for aircraft measurements.

The AES tunable diode laser system has been upgraded so as to measure nitric acid (HNO_3) and nitrogen dioxide (NO_2) down to about 0.1-0.2 ppb; concentrations commonly encountered in background air in rural areas.

An intercomparison of CAPMoN/APIOS filter holders for the collection of atmospheric particles and gases was carried out at Longwoods, Ontario. The results were compared by linear least square regression calculations, which indicated better than five per cent agreement between the two filter holders for all species. Duplicate analyses of the collected samples by OME and AES laboratories indicated no significant differences or biases between laboratories for the measured concentrations in these samples.

Contacts: K. Anlauf, A. Wiebe, J. Bottenheim

3.1.9 Data Analysis, Integration and Synthesis (DAIS)

The technique of combining daily observations of ambient air concentrations and wet deposition amounts, with the airmass trajectory climatology at selected Canadian monitoring sites, was further developed. The first empirical source-receptor relationships for NO_X were generated and clearly showed the influence of the major eastern North American urban centres. The source regions for SO_2 and NO_X producing the lowest pH values in the Quebec mountain fogs were also identified.

The concept of an atmospheric region of influence was developed for the Great Lakes Basin. Using the airmass back-trajectory database, maps were produced illustrating the concept for different periods up to five days back in time.

Maps of wet deposition of total nitrogen were produced for North America and Europe and clearly indicated much lower values (about one-half) in eastern Canada than over much of Europe.

The concept of the acidifying potential of wet deposition by accounting for the neutralizing effects of calcium and magnesium was further developed and applied as input to lake acidification models.

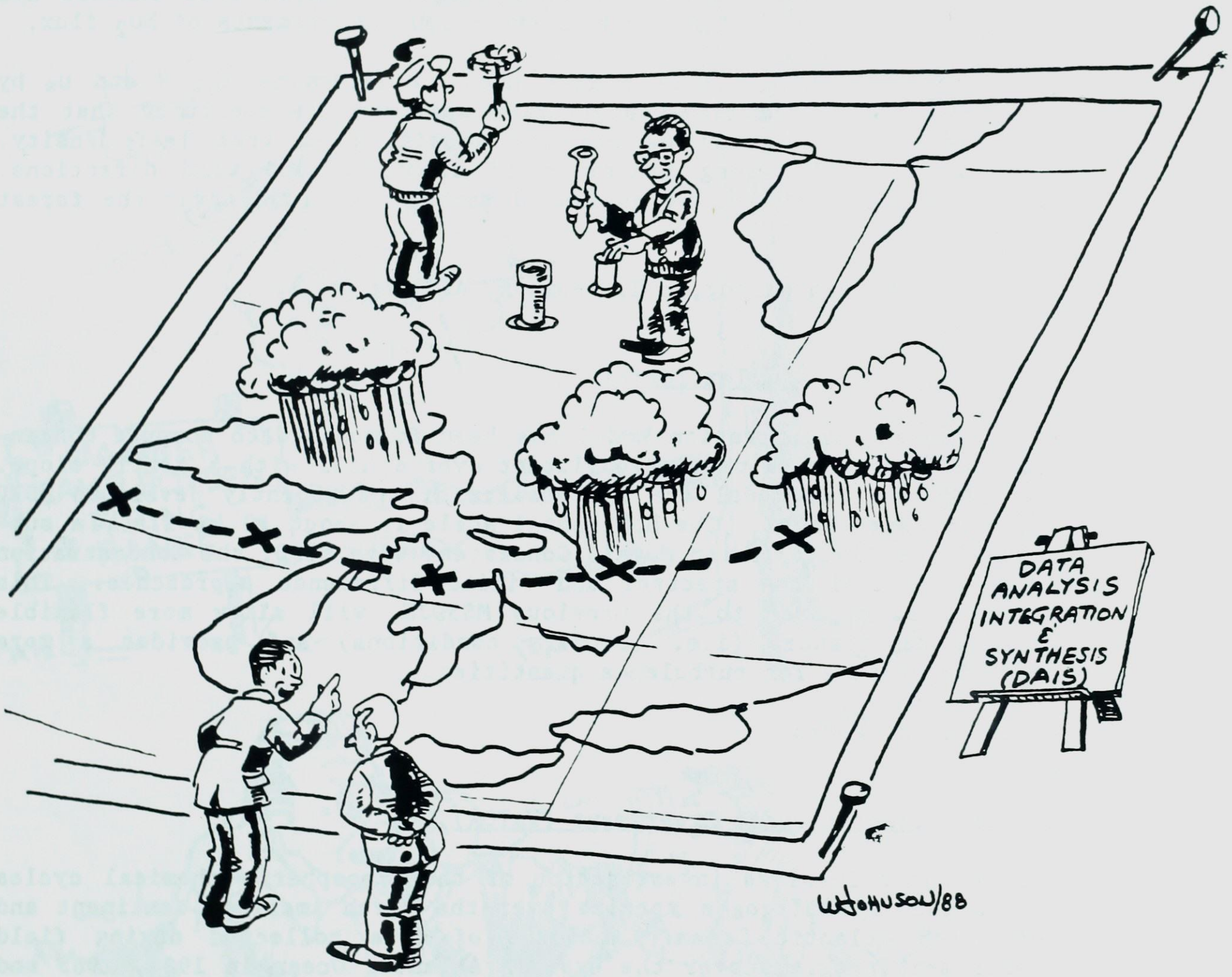
Contact: P.W. Summers

3.1.10 Dry Deposition - Forests

Operation of the Forest Dry Deposition Research Site at CFB Borden continued, marking the second full year of data collection at this location. Nearly continuous measurements above the deciduous canopy from the 43 m tower are available for wind, temperature, dew point, solar radiation, net radiation, ozone and sulphur dioxide as half hour averages back to autumn 1985 although only the 1985 and 1986 data have been quality controlled as yet. A CAPMoN air sampler has also been operated since the site was initiated, and filter analysis up to the end of 1987 has just been completed. Intensive field programs to directly measure the atmospheric fluxes of heat, water vapour, momentum, ozone and sulphur dioxide by eddy correlation were conducted in April for the leafless canopy, and periodically through June to August for the fully leafed canopy. The flux data is being used to parameterize the deposition processes which will allow us to compute seasonal and annual pollutant loadings from the continuous data.

In order to better understand and parameterize the turbulent transfer processes associated with forest-atmosphere exchanges, a study was started with Prof. Roger Shaw (University of California Davis) on forest canopy turbulence in the fall of 1986. Measurements for this study were completed during the summer of 1987. Early results for this work have been reported at the AMS Conference on Agricultural and Forest Meteorology at Purdue University last September, and in a Ph.D. thesis at the University of Guelph. Further results will be reported at the Eighth Symposium on Turbulence and Diffusion this April at San Diego.

Work on characterizing the forest at the Borden site also continued. Analysis of hemispheric photographs taken in the Fall 1986 has been completed to yield estimates of leaf area index and leaf area density profiles to complement the canopy turbulence measurements taken during the leaf-fall period. Stomatal resistance measurements at several heights and for several tree species were taken at weekly intervals through the spring-summer period to provide information on seasonal and diurnal patterns. Stomatal resistance is a key parameter in the dry deposition module of the Eulerian model, but one for which very limited data for forests exists.



WE'RE USING THE AIRMASS BACK-TRAJECTORY DATABASE, BUT THE MAPS ARE PRETTY EXPENSIVE TO PRINT.

The Borden site was again used for research related to carbon dioxide and climate change. Prof. Ken King (University of Guelph) operated a Bowen ratio apparatus to measure carbon dioxide fluxes over the forest.

Measurements at Borden will form part of the Eulerian model evaluation field study in the summer of 1988. Planning for forest dry deposition measurements for this study has been completed. In addition to the ozone and sulphur dioxide measurements flux estimates of nitrogen oxides will be made. Cooperating in this effort will be Ontario Hydro and the University of Guelph. In preparation improvements to Ontario Hydro's tunable diode laser system have been completed which will enhance its capabilities to be used for eddy correlation measurements of NO_2 flux.

The Camp Borden profile data were used to determine z_o, d and u_* by employing a modified mass-conservation approach. We concluded that the estimates of z_o, d and u_* are not sensitive to tree leaf density. They are instead strong functions of stability and wind directions. Using the above results we evaluated turbulence fluxes over the forest canopy.

Contacts: G. den Hartog, H.H. Neumann, A.K. Lo

3.1.11 Dry Deposition - Complex Terrain

A linearized Concentration Model has been formulated to compute concentration amounts of a passive pollutant over a hill with a gentle slope. The input to the model are the results of the recently developed MSFD Boundary Layer Model. The horizontal scale is about 10 km i.e., a subgrid of the ADOM Eulerian Model. Consistent with MSFD, the Concentration Model uses both the spectral and finite difference approaches. This version, as opposed to the previous MS3DJH, will allow more flexible surface resistances (i.e. boundary conditions) and provides a more accurate closure for turbulence quantities.

Contact: J. Padro

3.1.12 Western Atlantic Ocean Experiment (WATOX)

This project involves investigation of the atmospheric chemical cycles of sulphur and nitrogen species over the North American continent and the North Atlantic Ocean. Analysis of data collected during field measurement programs over the Western Atlantic Ocean in 1984, 1985 and 1986 has been completed. Continental emissions from Africa and North America can be detected frequently on an episodic basis in the mid-Atlantic and on Bermuda, depending on the prevailing flow regime. Under conditions of westerly flow from North America, distinctly higher concentrations of most anthropogenic pollutants are found in the boundary layer than in the free troposphere. The scavenging of the primary pollutants, SO_2 and NO_x, appears to be much more efficient within the first few hundred km off the coast than previously thought. Atmospheric budget calculations over the western North Atlantic show that less than 20% of North American sulphur and nitrogen, respectively, are transported beyond 66° W longitude.

YOU JUST HAD TO CHOOSE THIS OBSERVATION SITE.....

A sampling station has been installed on the northeast coast of Bermuda to measure major ionic species under easterly flow conditions, in order to determine background concentrations in air and precipitation over the North Atlantic. Preparations have begun for participation in the WATOX Coordinated Air-Sea Experiment in July and August 1988.

Contacts: D.M. Whelpdale, S. Melnichuk

3.1.13 Nitrogen Chemistry and Long Range Transport

Since June 1984 peroxy acetyl nitrate (PAN) has been monitored at the CAPMoN site in Kejimkujik National Park, N.S. The purpose of this project is a) to determine the role that PAN plays in the long range transport of oxides of nitrogen, b) to establish the seasonal variation in occurrence and magnitude of PAN episodes, as well as the intrinsic continental background of PAN, c) to determine the major contributing source regions to PAN and other oxides of nitrogen. Besides PAN, standard meteorological data are collected, the CAPMoN network determines nitric acid and nitrate aerosol, and Environment Canada's Conservation and Protection Service operates a Dasibi ozone monitor. During 1987/88 data collection continued, and data collected during 1984-1986 were analyzed and published. Several trends are emerging from the total data package, such as the springtime maximum in background O_3 and PAN, the increasing importance of PAN as a major carrier of the total oxides of nitrogen burden with aging of an air-mass, and the lack of a seasonal trend in the occurrence of PAN episodes.

Contact: J.W. Bottenheim

3.1.14 Differential Absorption Lidar (DIAL)

A DIAL system has been constructed at AES which is capable of detecting sulphur dioxide and ozone in the lower troposphere at ambient levels. The system is based on a Neodymium-YAG laser which pumps a dual wavelength dye laser which gives output at two wavelengths near 600 nanometers. These wavelengths are frequency doubled into the ultraviolet and correspond to sulphur dioxide absorption minima and maxima or two wider spaced wavelengths on the ozone absorption edge of the Hartley band. The laser pulse is sent into the atmosphere and the return from air molecules and aerosols is monitored as a function of time. From the time of flight, range is obtained and from the difference in intensity of the two wavelengths, the gas concentration can be obtained.

In 1987, the system underwent a testing phase for sulphur dioxide and initial testing for ozone was undertaken. Column content sensitivity for sulphur dioxide was determined to be 2 ppb-km which gives limited height resolution in the boundary layer at ambient sulphur dioxide levels of 5 - 10 ppb. Improvements to this sensitivity will be attempted during the Eulerian Model Evaluation Field Study (EMEFS) during 1988. During that project, ozone will be the priority species measured and will be monitored at the Centre for Atmospheric Research Experiment, (CARE), Egbert.

Contact: R.M. Hoff

I HOPE THEY CAN AFFORD A BIGGER RESEARCH VESSEL SOON....

3.1.15 Carbonyl Compounds

A second cooperative project between AES and York University was established to develop means to sample and analyze air samples for major carbonyl compounds, specifically formaldehyde, acetaldehyde, acetone, and possibly ketones derived from natural hydrocarbon photochemistry. The technique involves sampling of air via cartridges packed with DiNitro Phenyl Hydrazine (DNPH) coated silica gel, and analysis by High Performance Liquid Chromatography (HPLC).

A first application of the technique will be attempted for samples collected during the Polar Sunrise Experiment.

Contacts: J.W. Bottenheim, K.G. Anlauf, P. Shepson

3.1.16 The Integrated Environmental Simulation System

The Integrated Environmental Simulation System consists of a set of Numerical Weather prediction models with sophisticated parameterization of the atmospheric boundary layer and clouds and a 3-D Eulerian transport model capable of treating complex wet and dry phase chemical reactions.

The prototype version of the system was applied operationally immediately after receiving the first information about the Chernobyl accident. The initial simulation was performed on the hemispheric grid in a pressure coordinate system. Following the emergency simulation, the extensive development work with the environmental simulation system was conducted. The current version of the system is fully three-dimensional and can be executed on a grid with a horizontal resolution of 75 km over the Northern Hemisphere. The meteorological data for the simulation of the transport processes can be obtained from the hemispheric spectral model, finite element regional model or the objective analysis scheme.

The Integrated Environmental Simulation System is being currently implemented as an Emergency Response System in the Canadian Meteorological Centre. The potential applications of the system include simulation of nuclear accidents on global or regional scale, analysis of Arctic pollution problems and simulation of atmospheric chemistry.

The plan for the future is to extend the upper limit of the model to the stratosphere to simulate the stratospheric ozone layer. This version of the integrated system will be executed on a global grid.

The first stage of the work with the Integrated Environmental Simulation System is described in several reports which are available upon request.

Contact: J. Pudykiewicz

3.2 TOXIC CHEMICALS

3.2.1 Pesticide Off-Target Drift

Our objective is to model aerial sprays. To this end, we have obtained a computer program of the Atias-Weighs numerical model on aerial sprays over a forest canopy. We have installed the program on the PC Compaq computer and we are making preliminary test-runs. We plan to modify the original model to include vortex interaction with a forest canopy in a more realistic way.

Contact: A.K. Lo, A.J. Arnold

3.2.2 Atmospheric Loading

The spatial and temporal resolutions of the LRTOX model were increased. The effects of these improvements on deposition of nutrients and toxic chemicals to the Great Lakes is being evaluated. Temporal trends in lead deposition are being analysed. A contract for development of an air/soil exchange module for toxic chemicals was initiated and a cooperative study on deposition with Argonne National Laboratory is in its final planning stage. Deposition of sulphur and nitrogen to the Great Lakes and their basins was estimated from observations. Errors/uncertainties in deposition amounts caused by network design were investigated.

A strategy for compiling emissions inventories of priority toxic chemicals, defined by the International Joint Commission was jointly prepared by AES and C&P and adopted by C&P. Consultation was provided to Ontario Ministry of the Environment from its Toxic Chemicals Program.

A plan for assessing atmospheric deposition to the Great Lakes and a scientific background document were prepared by the Atmospheric Deposition Monitoring Task Force. The plan was presented to the Surveillance Work Group and the Water Quality Board of the International Joint Commission. Reports on production, usage and emission of toxic chemicals and emissions of the 14 priority toxic chemicals were prepared for the International Joint Commission and accepted for publication.

Preliminary studies on the relationships between fluxes and profiles over the Great Lakes have began. The aim is to evaluate surface fluxes which affect the deposition of aerosols and particulates.

We intend to carry out a field study over the Great Lakes to measure turbulence parameters over a non-stationary water surface. Initial trial runs are expected to commence during the 1988-89 fiscal year.

Contacts: E.C. Voldner, A.K. Lo, A.J. Arnold

3.2.3 Organic gas/particle sampler

Funding for a field sampling program (in cooperation with Dr. W. Strachan of the National Water Research Institute (NWRI), Burlington, Ontario, at Turkey Lake, Ontario, using the GAP sampler developed by the Ontario Research Foundation (ORF) was provided by AES and the Great Lakes Water Quality Program. A contract to measure background gas phase and particle phase concentrations of α-HCH, γ-HCH and HCB was awarded to the ORF. The field studies were carried out May 7 - 15, July 23 - 31 and October 19 - 27, 1987.

In an attempt to increase the sensitivity of the GAP sampler to the target compounds, the dichotomous sampler was replaced with a system which collected all of the particulate matter passing through the denuder on one filter and appropriate back-up traps. The samples collected during the May field trip have been analysed and the results show better precision and a significant improvement in the signal to noise ratio (ω10:1 for α-HCH and HCB) over previous results. Due to its very low ambient concentrations, the results for γ-HCH have improved only marginally. Improvements to the gas chromatographic analytical techniques have also resulted in greater sensitivity and greater reliability in the analyses.

Since PCBs were of interest in this sampling program, the Tenax traps used in previous field tests as back-up adsorbents for the filters, were replaced with Florisil traps. Although Florisil provides better trapping of the PCBs, it is not as efficient for the HCH isomers and HCB during periods of high humidity and rain. Methods to rectify this shortcoming were investigated.

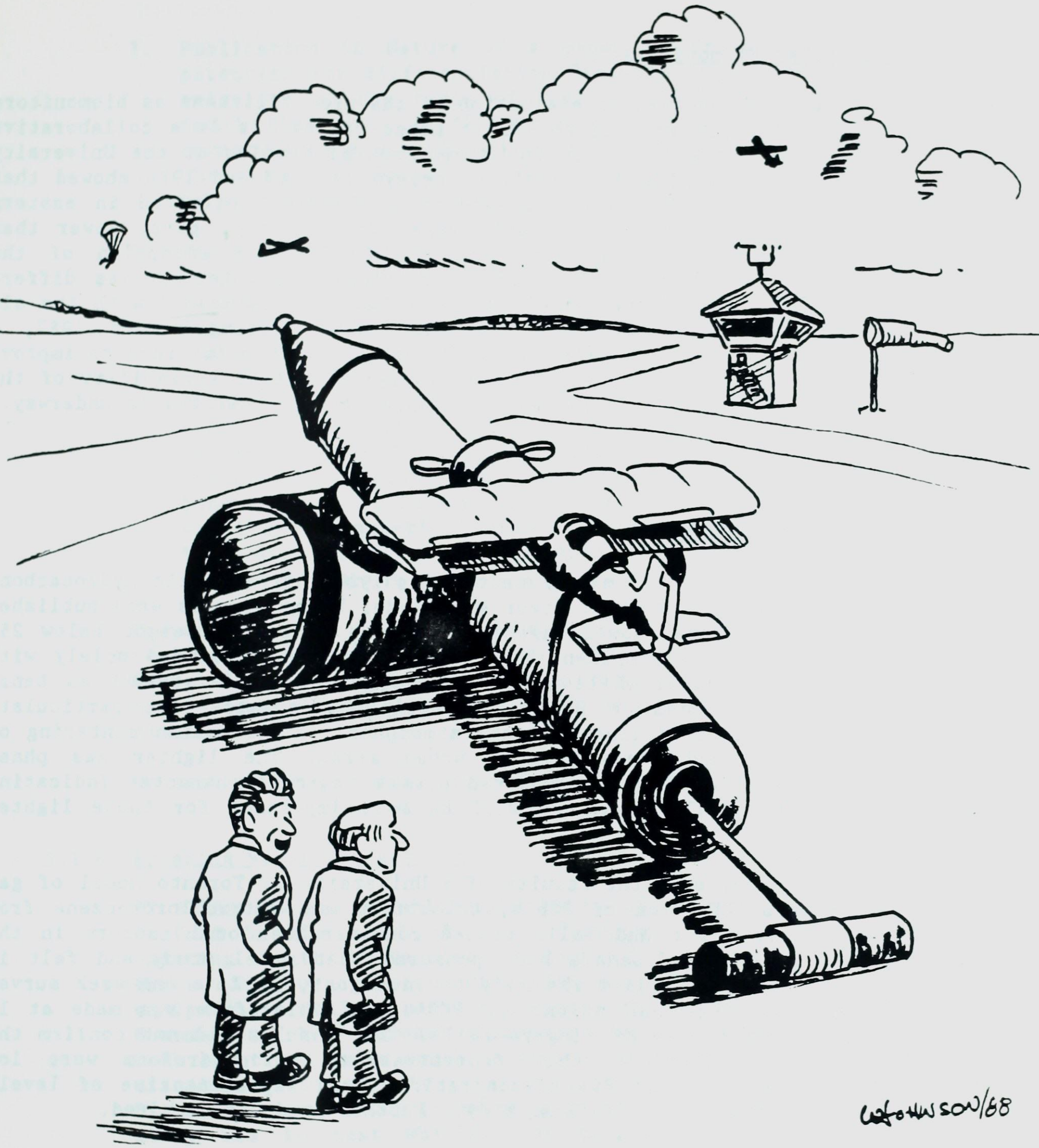
The desorption of the target compounds from the denuder for a direct determination of the gas phase is turning out to be a very difficult problem. To date, the recovery efficiency for HCB is about 50%. Work is proceeding to improve the recovery efficiency.

Contacts: D.A. Lane, W.H. Schroeder

3.2.4 Spray Mapping Project

During 1987, the new AES Rapid Acquisition Lidar system (ARAL) was developed which has the capability to map the spray from agricultural and forestry aircraft immediately after passage. Taking cross-sectional scans in a vertical plane, the ARAL obtains a 30 shot contour of the spray cloud every six seconds for two minutes after passage. The contours can be displayed in colour contours in a real time mode. During the 1987 NRC Symposium on the Aerial Application of Pesticides in Forestry in Ottawa, applicators and researchers were shown results of the August 1987 New Brunswick Spray Study with a computer demonstration. The contours of the spray cloud were shown in a real-time mode and aircraft pilots could visualize what was happening behind their aircraft. Coupled with the results from the Pesticide Modelling project, these results will be used to determine the ratio of deposition to drift as a function of aircraft type, spray nozzle type, and atmospheric parameters. The ultimate goal is to provide regulators with better information on the atmospheric regimes which minimize off-target drift.

Contacts: R.E. Mickle, R.M. Hoff



I BELIEVE BIGGER IS BETTER.... NOW ALL I HAVE TO DO IS GET THE THING OFF THE GROUND.

3.2.5 Lichens as Biomonitors

This project involves an evaluation of the use of lichens as biomonitors of organic pollutants in the Great Lakes basin. It is a collaborative project with the Institute for Environmental Studies at the University of Toronto. Results from earlier surveys in 1985 and 1986 showed that concentrations of organic pollutants in lichens collected in eastern Canada and the Upper Lakes basin were, for the most part, lower than those measured elsewhere in the world with the exception of the Antarctic. Measurements do show geographical and inter-species differences in concentration, which are now being investigated with the aid of meteorological emissions and other data. During summer 1987, a second collection was made in the Upper Lakes basin in order to improve sample representativeness and to investigate spatial variability of the scale of 10s to 100s of metres. Analysis of these samples is underway.

Contact: D.M. Whelpdale

3.2.6 Niagara Falls Study

During 1983 and 1984, measurements of polynuclear aromatic hydrocarbons in air along the Niagara River were made. These results were published in 1987. The data showed that species with molecular weight below 252 had a gas phase component which could not be monitored solely with particulate filters while higher molecular weight PAH's (such as benzo (a) pyrene) tended to be predominantly particulate. The particulate species showed a distinctly local atmospheric distribution centering on the Buffalo and Niagara Falls urban areas. The lighter gas phase species, such as phenanthrene, had a more regional character indicating that larger scale transport will be more important for these lighter PAH's.

In 1987, reports of the results of a University of Toronto model of gas phase volatilization of PCB's, chloroform and tetrachlorobenzene from the Niagara River and Falls caused considerable local concern in the area. Environment Canada had sponsored that model study and felt it was prudent to validate the model. In August, 1987, a one-week survey of gas phase concentrations of PCB's and chloroform was made at 10 sites within 1.5 km of Niagara Falls. The results did not confirm the model predictions in that concentrations of chloroform were low (100-220 ng m^{-3}) and PCB concentrations were representative of levels found in urban areas (2-11 ng m^{-3}). Further study is required.

Contact: R.M. Hoff

3.2.7 Regional Aerosol Composition Studies

This year saw the completion of analysis and reporting of studies conducted in previous years. These include:

1. Publication in Nature of a paper by Sturges and Barrie on the potential for differentiating Canadian and American automobile lead emissions on the basis of their 206/207 isotopic ratios. It was found that due to different sources of lead additives the two countries have markedly different lead isotopic signatures, Thus in the autumn at Dorset Ontario it could be concluded that the split between Canadian and American auto lead was approximately 52/46.

2. The above study was extended to Montmorency Forest north of Quebec City and to Kejimkujik National Park in Nova Scotia in a paper to Tellus by Hopper and Barrie. The split between Canadian and American auto lead at these two sites was 67/28 and 51/44 respectively.

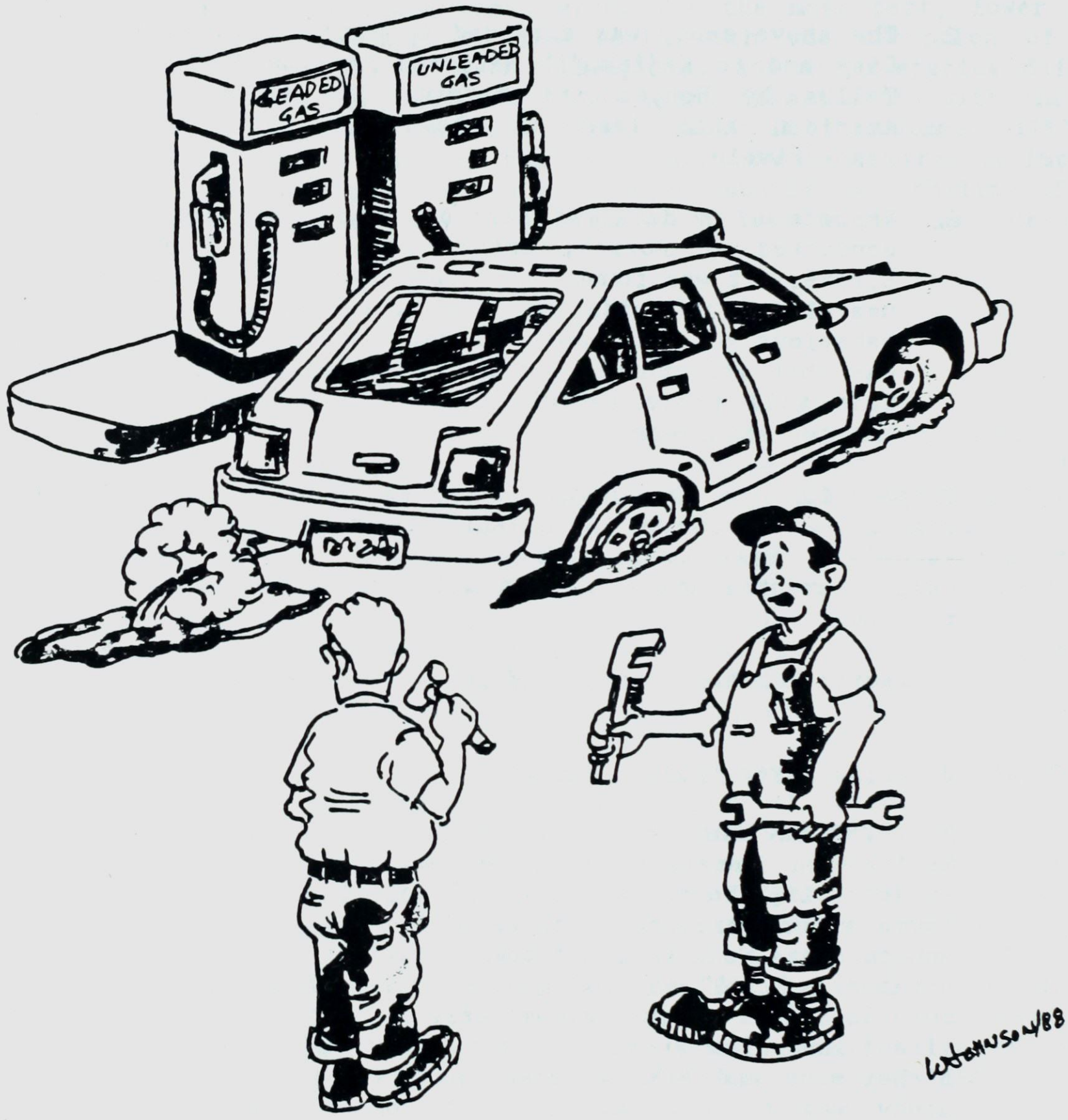
3. Results of a detailed aerosol and precipitation chemistry study conducted at Dorset, Ontario in autumn 1984 were published by Barrie. It was found that trace elemental composition is extremely useful in elucidating the sources and atmospheric chemical behaviour of pollutants in the Atmosphere. One important finding was that atmospheric Indium is a good tracer of northern smelters. This will prove useful in acid rain studies of the impact of smelter emissions.

Preparation of hi-volume sampling equipment for distribution at regional sites during the Eulerian Model Evaluation Field Study (EMEFS) 1988-1990 was made. The intention is to collect aerosols for multi-elemental analysis on a daily basis during the intensive studies planned.

Contacts: L.A. Barrie, F. Hopper, J. Kovalick

3.2.8 Breaking Waves Project Report

FY 87/88 saw the establishment of an air sampling trailer facility at Meaford on the south shore of Georgian Bay some 50 km upwind of an existing lighthouse facility on Double Top Island in southwesterly flow. These sites were instrumented with aerosol and meteorological sampling equipment as well as radio communications between sites. In October and November of 1987 aerosol chemistry sampling was done simultaneously at both locations under southwesterly flow (to ensure air transport between sites) and wind speeds greater than 7 m/s (to ensure breaking waves). Dichotomous and PIXE streaker samplers were operated. The aim of the study was to test whether the composition of atmospheric aerosols changed substantially during passage over 50 km of white-capped water. Bubble-bursting processes that effect the suspension of lake water upon bursting is well established. Upon evaporation of the water droplets thus suspended lead to a solute residue. The question is how important is this source in releasing toxic particulate substances from a Great Lake to the atmosphere.



SAM... YOU'D BETTER PHONE THE GAS COMPANY... TELL EM TO CUT BACK A BIT ON THE LEAD ADDITIVES.

Preliminary analysis of results indicate that the enhancement of particulate Pb, Br, Ca, K, Cl, S, Si, V, Mn, Fe, Cu, Zn and Se by freshwater lake spray is not detectable within the accuracy of measurement.

In FY 88/89 results will be fully analyzed using a 1-D air/lake exchange model and reported. In addition a characterization experiment of aerosol enrichment over the lake using an artificially generated air bubbler will be performed.

Contacts: L.A. Barrie, F. Fanaki, B.R. Kerman

THE GREAT LAKES....
A WITCHES CAULDRON?

Fair is foul, and foul is fair
Hover through the fog and filthy air.

Double, double, toil and trouble
Fire burn, and cauldron bubble.

Macbeth... Shakespeare.

3.3 CLIMATE CHANGE

3.3.1 Alert Research Station

Radiatively Active Gases (RAGS) Monitoring

In 1986, Alert became Canada's first permanent research station for the continuous monitoring of background air pollution. The laboratory is part of an international network of stations coordinated by the World Meteorological Organization (WMO) under its Background Air Pollution Monitoring Program (BAPMoN) to study the long-term effects of pollution on our atmospheric environment. Both continuous measurement and flask sampling programs were maintained and augmented at Alert in 1987.

The continuous monitoring program at Alert included sampling of such chemical species as carbon dioxide (CO_2), methane (CH_4), ozone (O_3), and peroxyacetyl nitrate (PAN). The importance of PAN lies in the following:

1) it is probably the main oxide of nitrogen during the arctic winter,

2) it is an indicator of the chemical history of air masses arriving at Alert.

Weekly CO_2 flask sampling continued in 1987 at Alert, Sable Island and Cape St. James. In addition to the already existing cooperative flask sampling program at Alert with other nations, new cooperative research programs have been established with Dr. Jim Elkins of NOAA/GMCC for freons and N_2O, and with Dr. Ingeborg Levin and Dr. Dietmar Wagenbach (University of Heidelberg) for radon gas and ^{14}C isotope respectively.

Radon gas (colourless, odourless) is emitted continuously in small quantities from the ground; thus, measurements of its concentration in air will give an indication of the amount of time the air mass has spent over continental source regions and can be used as one of the criteria to establish baseline conditions. An instrument for continuously monitoring radon has been developed by the University of Heidelberg and is used widely in Europe to monitor radon gas. A radon detector has been acquired from the University and a set of preliminary tests will be conducted at the Egbert Station before being shipped to Alert.

Both the continuous and weekly measurements are supervised by several scientists from different agencies.

A new pressurized flask sampling system was installed at Alert in 1987. Unlike many other flask programs, the samples taken at Alert may be dried cryogenically through the same system as the NDIR sample gas, or chemically through a separate drier.

Contacts: N.B.A. Trivett, J.W. Bottenheim

3.3.2 Alert Measurement Program for PAN and Ozone

Data collection for these species continued during the past year, and starts to indicate very important results such as the occurrence of high levels of PAN during the Arctic haze season. It has been confirmed and it becomes now well established that PAN is a major oxide of nitrogen at this remote site. The mysterious episodes of major ozone disappearance in the spring was again observed in 1987. A theory was developed to explain this, and this led to the staging of the Polar Sunrise Experiment.

Contacts: J.W. Bottenheim, N.B.A. Trivett

3.3.3 Arctic Haze

Aerosol black carbon (BC), which normally results from incomplete combustion of carbonaceous fuels, has been associated with the phenomenon of Arctic haze. Measurements of BC are useful in evaluating whether or not the air mass has anthropogenic input from high temperature combustion sources, e.g. high CO_2/CH_4 and low carbon black content indicates high temperature combustion. Therefore, continuous measurements of BC can enhance the ability to interpret the variations in the CO_2/CH_4 concentrations, as well as the Aitken nuclei and nephelometer readings that are routinely taken at Alert, N.W.T. In addition, the monitoring of the black carbon loading in the atmosphere is important, since BC can significantly alter the atmospheric radiative balance.

A carbon black sensor which gives real-time measurements of BC aerosol has been acquired. After laboratory trial runs of real-time monitoring of BC with an aethalometer in January, 1988, field tests with the equipment commenced at Alert in February. It is intended that a similar unit will be installed at the Egbert Station before the end of 1988 for monitoring urban BC concentrations.

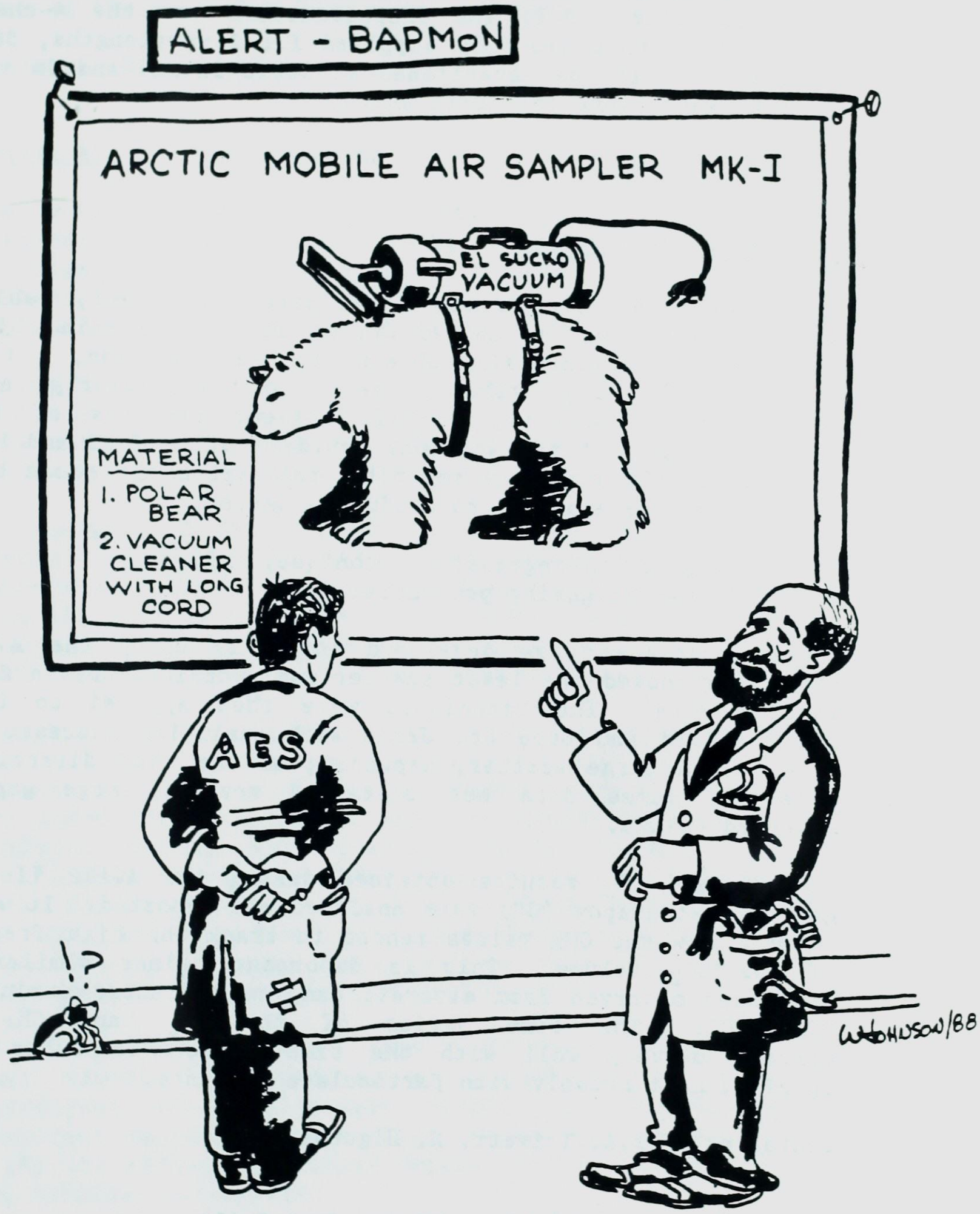
Contacts: N.B.A. Trivett, L.A. Barrie

3.3.4 Carbon Dioxide Flux Studies

This is a continuing cooperative research program with Prof. K. King of the University of Guelph to develop alternative methods for measuring CO_2 fluxes to forests. The gradient-flux equipment was set up at the dry deposition study site at Camp Borden.

During 1987, CO_2 flux measurements were made at the site from April to October using a Bowen-ratio energy-balance approach. Gradients of temperature, water vapour and CO_2 concentrations were measured over a 4 m height difference above the forest using a reversing arm assembly.

Contacts: N.B.A. Trivett, H.H. Neumann, G. den Hartog



YOUR PLAN HAS SOME MERIT, BUT, I THINK IT NEEDS A BIT OF FINE TUNING.

3.3.5 Turbidity

New sunphotometers have been installed at Cape St. James, B.C., Edson, Alta., Wynyard, Sask., Peterborough, Ont., Maniwaki, Que., and Hall Beach and Alert, NWT. The Sunphotometers are the 4-channel Sonotek type, but filters are only supplied for 2 wavelengths, 380 nm and 500 nm. Stations will be established at Sable Island and in eastern Quebec (Baie Comeau) along the North Shore.

Contact: S. Iqbal

3.3.6 Analysis of CO_2 and CH_4

Time series analysis of CO_2 flask data from Alert, Sable Island and Cape St. James was conducted during 1987. The main objective of the study was to statistically obtain, for each station, a time series of mean monthly CO_2 values, based on irregularly spaced weekly observations. This way certain salient features of the CO_2 time series at each of the stations would be identified and be real enough so that certain questions regarding the carbon cycle can be asked. Two techniques were employed to study the series,

1) stepwise multi-regression technique, and
2) nonlinear weighting procedure.

These techniques were developed initially using the Alert CO_2 data set which showed the least scatter and contained only a few months with missing data. The techniques were then applied to CO_2 data from Sable Island and Cape St. James with qualified success. Sable Island data showed large scatter, depending on the wind direction, while the Cape St. James data set contained several large gaps of missing observed values.

The CH_4 and CO_2 results obtained during the AGASP II experiment by gas chromatography (GC) were analyzed and reported. It was interesting to note how the CH_4 values tended to track the high frequency pattern of the CO_2 values. This is important, since similar correlations have been observed from aircraft samples collected during AGASP II by NOAA/GMCC. The time series of the CO_2 and CH_4 values also correlated very well with the time series of other anthropogenic species, most notably with particulate sulphate.

Contacts: N.B.A. Trivett, K. Higuchi

3.3.7 Carbon Dioxide and Methane Fluxes from Soils

A contract was issued to T.R. Moore (McGill University) to survey the literature of CO_2 and CH_4 fluxes from soils, with particular reference to Canadian ecosystems. The main results show that temperature and moisture are two important factors which influence the CO_2 and CH_4 fluxes from soils.

Contact: K. Higuchi

3.3.8 Ocean Modelling and Global Carbon Cycle

A contract was issued to C.A. Lin (McGill University) to survey the literature of ocean models used in carbon cycle studies. The formulation of the model has been completed and reviewed.

Contact: K. Higuchi

3.3.9 Arctic Air Chemistry Studies

The routine aerosol chemistry sampling initiated at Alert in July 1980 continued through 1987/88. Weekly samples were collected and with the assistance of a summer student a data analysis and quality control software package was set up to use with the aerosol chemistry data. It was used to analyze data from 1980 to 1986 at Alert.

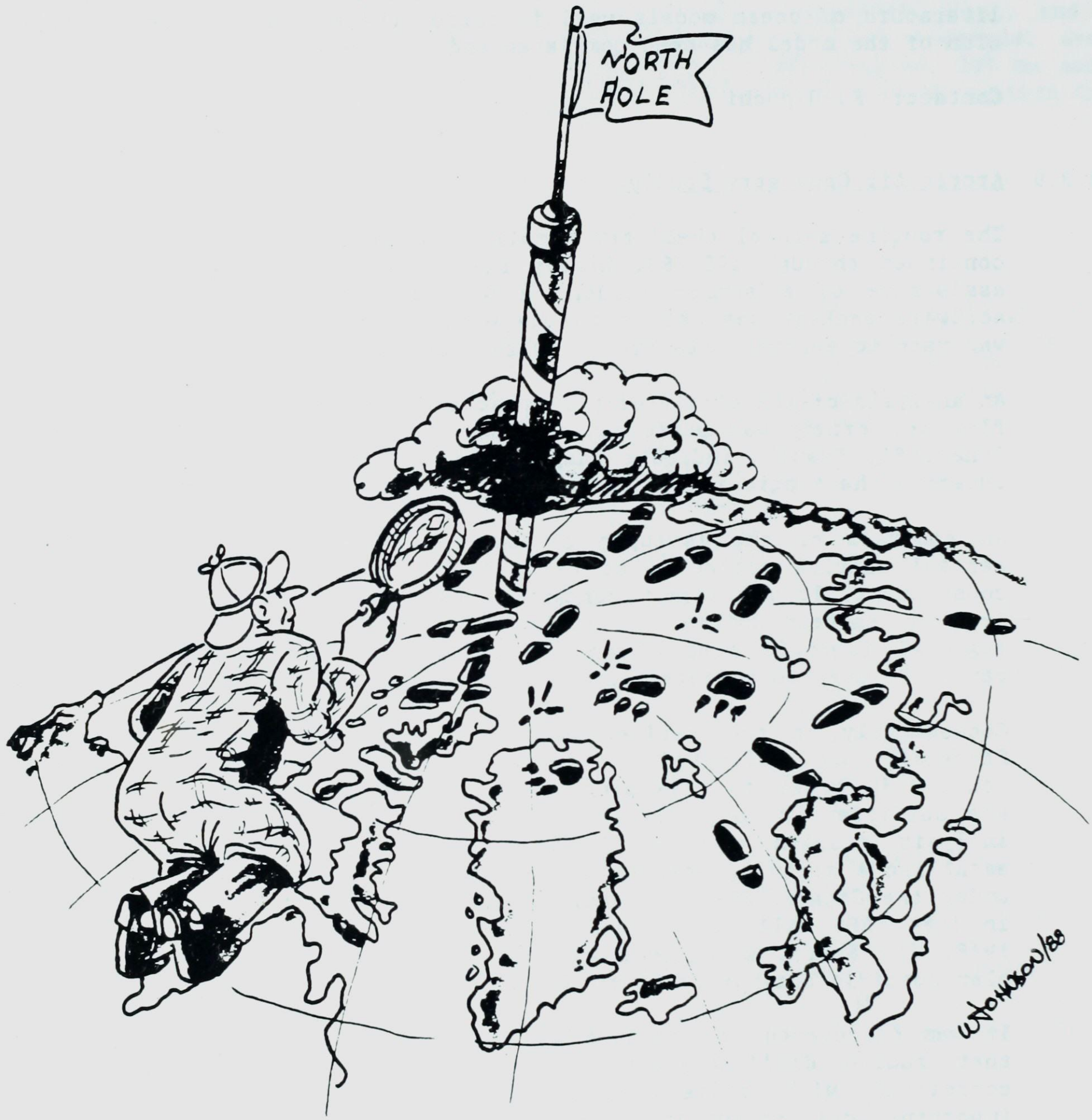
An analysis of the origin of pollutant sulphur entering the Arctic, its flux and origin was performed for the case study year of July 1979 to June 1980. Results indicate that over 95% of the anthropogenic sulphur entering the Arctic is from Europe and the western Soviet Union.

An analysis of the isotopic composition of lead was conducted using aerosol samples collected at Alert to investigate the origin of the constituent. It was firmly concluded that Arctic aerosol lead was not from the eastern United States. However, until more is known about the regional isotopic composition of lead aerosol in Eurasia the results cannot be used to differentiate sources within that region.

Consequently, a cooperative research program with the University of Stockholm was initiated to collect aerosols downwind of European sources in order to determine whether regional differences exist and are sufficiently large to make the Arctic analysis useful. The Arctic analysis results were prepared by W. Sturges. Work continued to establish a standing working group on Arctic air pollution and climate under the Canada/USSR bilateral agreement on Arctic cooperation signed in 1984. AES will host the first formal meeting of the group in June 1988. Six Soviet scientists will be joined by Canadian scientists to plan specific activities of mutual benefit.

It was discovered in the 1986 AGASP II field study (see publications) that sudden disappearances of ground level ozone are negatively correlated with filterable bromine in the atmosphere. This has important implications for ozone chemistry. A project was initiated to study the spring 1988 polar sunrise period at Alert, involving American and Canadian scientists.

Contacts: L. Barrie, M. Olson, K. Oikawa, J. Kovalick, W. Sturges



HOT ON THE TRAIL OF POLLUTANTS
ENTERING THE ARCTIC

3.4 CORE RESEARCH

3.4.1 Flow Over Complex Terrain

A chapter on meteorological considerations for an International Energy Agency handbook, Site Assessment for Decentralised Wind Energy Conversion Systems and an outline for a Canadian Standards Association publication, Recommended Practices for Siting of Wind Energy Conversion Systems, were prepared.

Development of a new method of converting topographic contours to grid-point values has been completed. Improved numerical techniques in the MSFD model and a "user-friendly" microcomputer version of the MS3DJH model are nearly complete. The Kettles Hill and Askervein Hill Project data analyses have been concluded and the results are in press or have been published.

The "Guidelines for Estimating Wind Speeds" have been improved, a calculation of turbulence intensity has been added and a paper has been submitted for journal publication. These developments were presented in seminars to the AES Regions. Software for both the Guidelines and the MS3DJH model code have been widely distributed in Canada and abroad.

A method for calculating surface fluxes and wind-speed profiles over the sea has been developed. The technique allows estimates of wind speed at a given height to be derived from measurements at another height.

Contacts: J.L. Walmsley, P.A. Taylor

3.4.2 Canada Olympic Park (COP) Study

A report on data collected during the winter of 1986-87 was submitted to AES Western Region. The report noted that there was a potential wind problem at COP and recommended a detailed wind-tunnel study of the situation and the provision of a wind break at the site. Events proved that there was indeed a problem as several competitions had to be postponed during the 1988 Olympic Winter Games.

Contact: P.A. Taylor

3.4.3 Canadian Atlantic Storms Program (CASP)

A test of anemometers and data loggers from the CASP field experiment was concluded. Campbell Scientific now believe that occasional wind speed 'spikes' found in some of the CASP mesonet data result from electrostatic effects related to the propeller material and would only occur in certain atmospheric conditions. They are currently testing a filter circuit to eliminate the problem. R.M. Young have also developed a shielded coil which we are testing.

LOOK OUT!!
HERE COMES ANOTHER ONE
OF THEM CRAZED OLYMPIANS.

A detailed comparison is being made of winds observed at a Minimet buoy, 30 km offshore from Martinique Beach, Nova Scotia, and at coastal stations of the Halifax mesonet. A report on the Portable Air Quality and Meteorological Observation System (PAQMOS) post has been completed and the CASP mesonet data report is nearing completion.

Contact: P.A. Taylor

3.4.4 Fonthill Kame Feasibility Study

This is a collaborative study with Ontario Ministry of the Environment and Brock University climatologists in a study to determine the feasibility of modelling the microclimate of this low hill on the Niagara Escarpment, which has a favourable microclimate for tender fruit production. A committee report is in preparation.

Contacts: P.A. Taylor, H.W. Teunissen

3.4.5 Pickering Nuclear Generation Station Demonstration Project

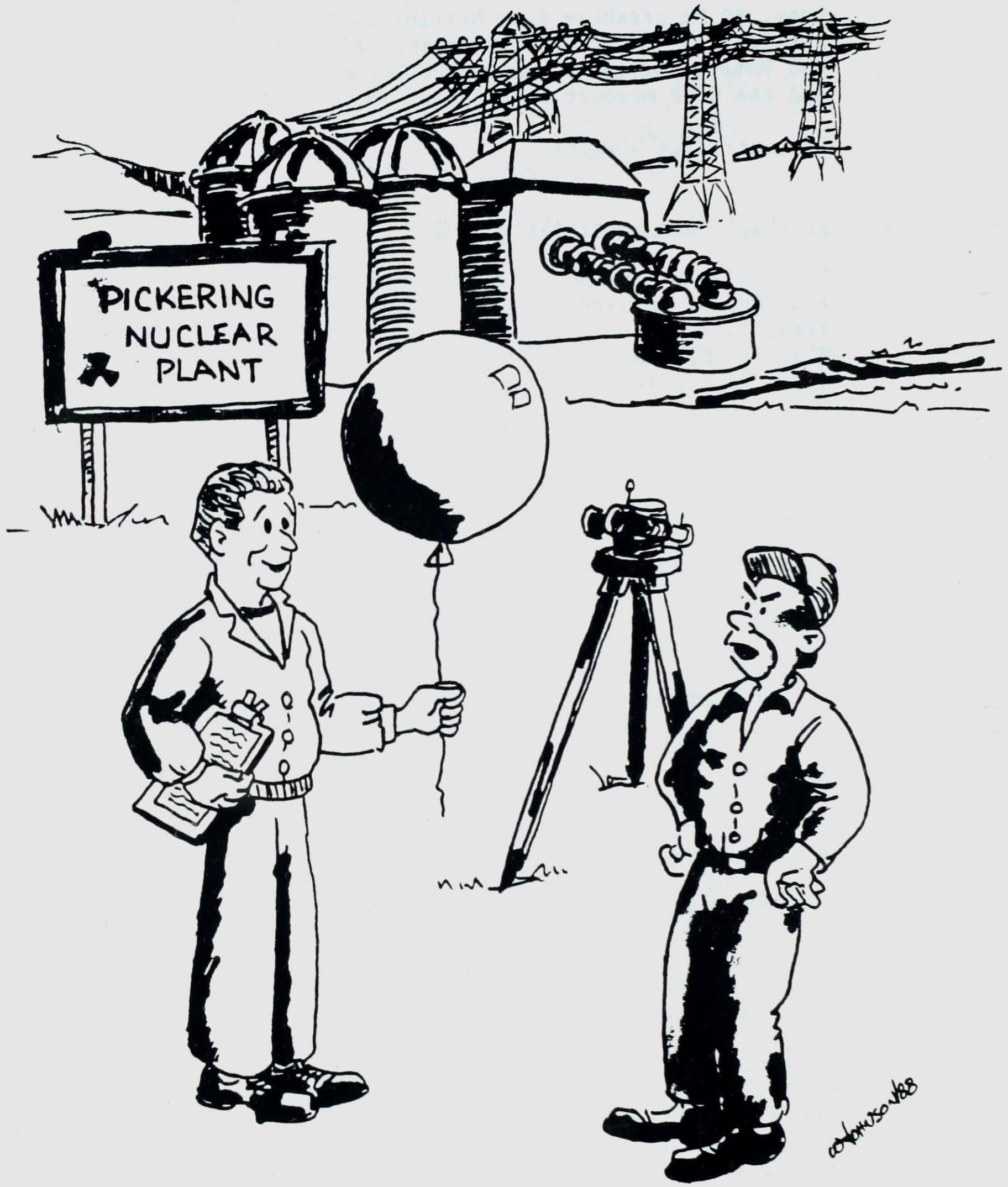
This is a joint project with Atomic Energy Control Board. A temporary, network of 9 Portable Air Quality and Meteorological Observation System (PAQMOS) automatic weather stations and a 26-m profile tower has been installed and data are being collected on a continuous basis. The purpose of the project is to collect 12 months of data for safety analysis purposes and to demonstrate how the network would assist in responding to emergency situations at a typical generating station.

Contact: P.A. Taylor

3.4.6 Gas and Particle Transfer by Natural Bubbling

Several experiments were conducted this year in an attempt to estimate the flux of gas and aerosols emitted to the atmosphere as a result of natural bubbling in lakes or oceans. As support to estimating such fluxes across the Great Lakes water-atmosphere interface, a study into the measurement of air entrainment by breaking waves was undertaken. This project in conjunction with the NATO Anti Submarine Warfare (ASW) Research Centre in La Spezia, Italy was conducted in the Mediterranean near Elba in February 1987. The objective was to utilize specialized sea acoustic equipment to analyze the air entrainment. Although the analysis is ongoing the experiment was successful in that it clearly identified a low frequency source associated with entrained bubble clouds. The plan is to develop this important unique technique in a study in Lake Ontario and at the Canada Centre for Inland Waters in conjunction with scientists from NATO, the U.S. Navy and Marconi, U.K.

A related study was conducted in Georgian Bay using an upwardly pointing sonar to determine the depth of bubble clouds and to examine the validity of a published model by Dr. B. Kerman on aerosol generation and enrichment in the related whitecapping. Unfortunately a cabling problem and inclement weather forestalled its use until 1988.



EVERY TIME YOU POP YOUR BUBBLE GUM OR BURST A BALLOON, MY BLOOD PRESSURE GOES UP 50 POINTS.

A workshop was organized at the University of Toronto in December, involving scientists and regulators from the Federal and Ontario Governments and scientists from several universities as well as observers from the municipality of Niagara Falls, to examine the status of research on the volatilization of toxic gases from the Niagara Falls. There were discussions of the recently identified foam enrichment in the gorge. The workshop was able to assemble a proposed list of desirable research bearing on both the gaseous and particle flux problems.

Contact: B.R. Kerman

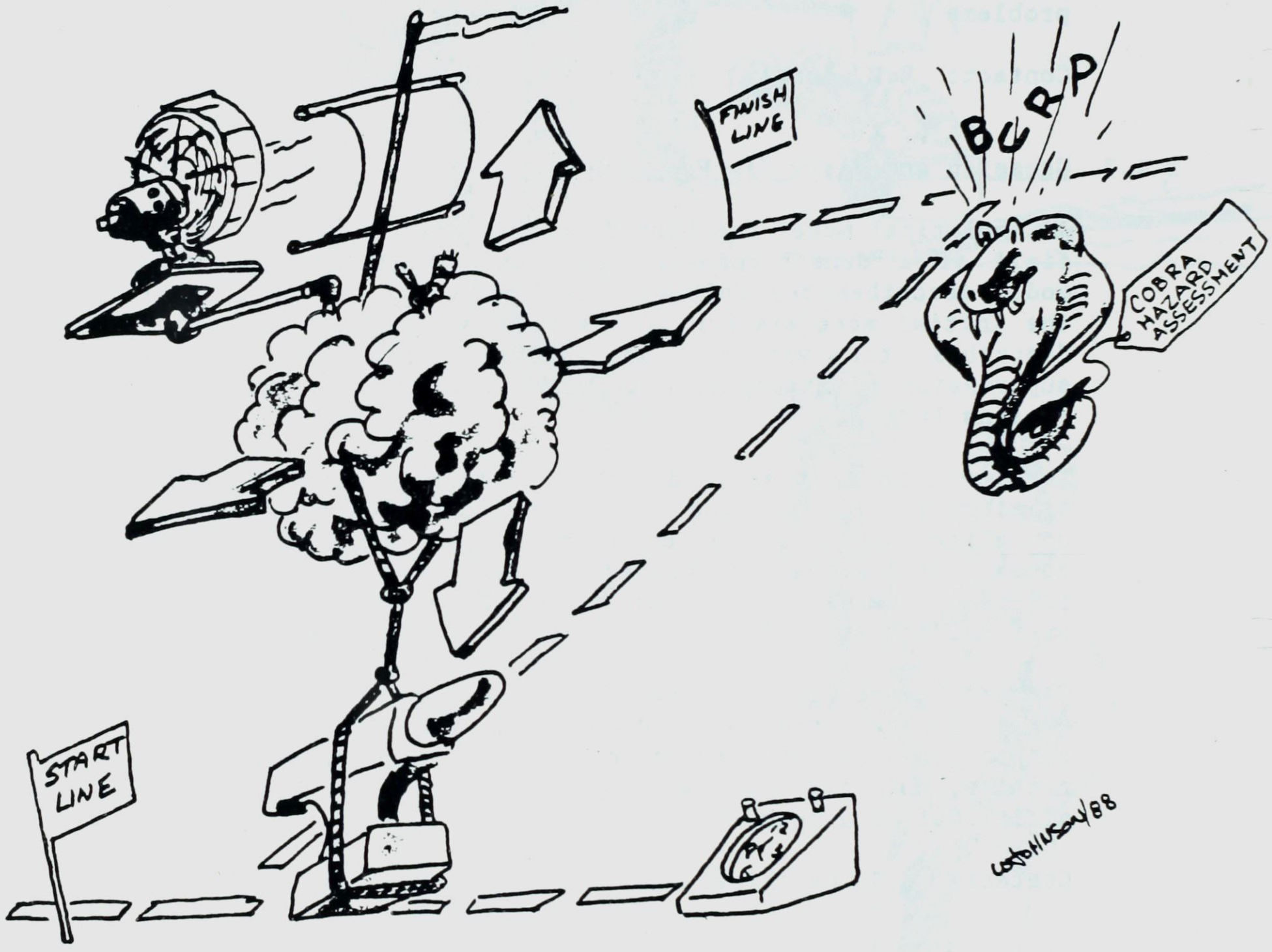
3.4.7 Gaussian and Heavy Gas Research

An analytical model has been developed which describes the concentration field of a denser-than-air gas cloud released instantaneously. The model describes the initial acceleration of the radial puff growth and the initial acceleration of the puff as it is pushed by the wind. It describes the vertical and lateral entrainment of air and the suppression of atmospheric turbulence while the puff Richardson number remains large.

The model is at present designed to calculate the maximum puff concentration as a function of time (or location), the time-varying concentration at a fixed receptor, and vertical and lateral hazard zones. It has been calibrated against numerous experiments ranging in release volumes from 0.035 m^3 to 2100 m^3 and shows good agreement over all scales.

Concord Scientific Corporation (CSC) has continued contract work on the COBRA hazard assessment dense gas model. They have improved the computation of streamwise dispersion, the tabular presentation of results, and the user guides. The model has been evaluated against additional data sets.

Contact: C.S. Matthias



THE LITTLE "*DENSER-THAN-AIR*" PUFF
THAT GREW...

3.5 AIR QUALITY SERVICES

3.5.1 Environmental Emergencies Program

Progress had been made in several areas of the national and departmental programs this year. An action plan was approved by AMC April 30, 1987 to develop the program in five areas: policy, operational systems, communications, training, and Service plans and procedures. The DOE Policy for Peacetime Emergency Response was approved by the Environment Management Committee in January 1988, following extensive coordination and review by Service components. Responsibilities were reviewed in the context of existing and proposed legislation. Environmental emergencies had been redefined as environmental pollution emergencies to distinguish between these and other environmentally related events such as severe weather.

Significant progress was also made in the development of emergency response techniques. The Emergency Weather Station concept had been put forward and a prototype (EWS1) developed and tested. The Air Quality Package of Programs (AQPAC) for use by regional meteorologists had undergone further development at headquarters and in Central Region and Version 5 will be completed shortly (see section 3.5.2).

Preparations began for a national training workshop in April 1988. Participants include AES regional and headquarters representatives and those from other federal agencies with responsibility during atmospheric pollution emergencies.

A first draft emergency preparedness contact list had been compiled. Preparation of a draft Operations Manual began in which an appropriate state of preparedness and response capability by AES will be defined. Proposed minimum action had been drafted in the context of levels of response which vary with the space and time scale of an event. Past responses by AES have been evaluated.

Recommendations relating to atmospheric nuclear emergencies were put forward in a departmental submission to the Ontario Nuclear Safety Review. Interim procedures for international early notification and transmission of meteorological, source and radionuclide data via the Global Transmission System (GTS) have been established for Canada and tested. AES Downsview, the national GTS Centre, is the first point of contact and notifies the national contact at Health & Welfare. Relevant model output and atmospheric data are being considered for realtime transmission to other countries.

Contact: E.E. Wilson

3.5.2 Modelling Studies for Environmental Emergencies

An updated version of AQPAC (version 5) was developed. The main modification was to the Source Strength model of AQPAC. The phenomenon of "flashing" for liquids with low boiling point is now included. The chemicals directory was updated and it is now coupled to the Source Strength model for efficient use in response to emergencies. The model results are being verified against some case studies published in the literature.

AQPAC's puff model validation study using the Savannah Research Laboratory field experiment data set (MATS) was completed. A report describing the study and results is being prepared. Surprisingly, at a downwind distance of about 30 km, the average predicted exposure and peak concentration were well within a factor of two of the observed values.

A research project with Dr. R. Sellers of Agriculture Canada on the Foot and Mouth Disease (FMD) outbreak of 1951-52 in Saskatchewan, using AQPAC's plume model, was also completed. We proved that the transport and dispersion of infectious viruses and their count were favourable for initiation of FMD at certain farms in Saskatchewan.

A technical report for the Ontario Nuclear Safety Review was also prepared.

Contacts: S.M. Daggupaty, D.L. Bagg

3.5.3 Environmental Impact Assessment (EIA)

The Climatological Dispersion Model (CDM) was modified so as to use either (1) the standard deviation of vertical fluctuations instead of stability class or (2) a description of local surface roughness in addition to the usual STAR program input. This work was done in cooperation with the Scientific Services Division - Ontario Region.

The Industrial Source Complex Short Term and Long Term models (ISCST and ISCLT) were applied to determine hourly average and annual average concentrations around a proposed incinerator.

Contact: C.S. Matthias

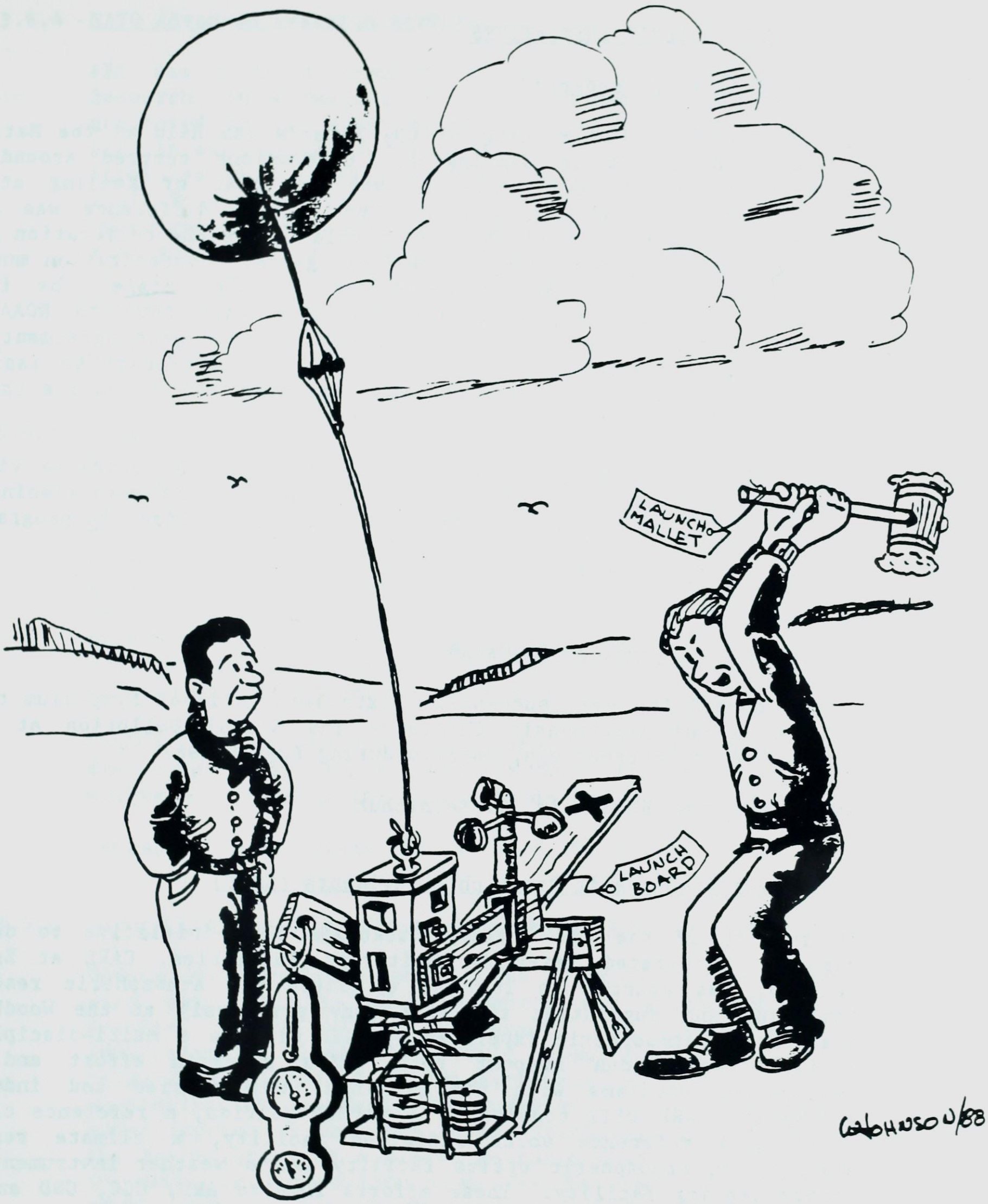
3.5.4 Beukers Upper Air Sounding System

Surface meteorological sensors for wind, temperature, humidity and pressure were interfaced to the upper air sounding system using the Campbell 21X micrologger. This allows for automatic input of the surface weather conditions during the pre-launch flight program.

A software plotting package using the tethersonde plots as a model, was modified and incorporated into the master program to provide on-line data analysis.

Other software changes were implemented to optimize the menu driven software such as, converting the system to run from fixed disk instead of floppies, changing data output format and converting archived files to ASCII.

Contact: F. Froude



OUR ONLY PROBLEM SO FAR IS THE WHOLE THING COMES BACK DOWN AGAIN.

3.6 ATMOSPHERIC SCIENCE INITIATIVES

3.6.1 WMO Meeting of CO_2 Experts

On June 15-17, a WMO Meeting of CO_2 Experts was held at the National Bureau of Standards in Washington. Discussions centred around the differences in the CO_2 scale of NBS and that of Keeling at the Scripps Institute of Oceanography. The average difference was about 0.5ppmv. It is understood that NBS should supply the calibration gases to international laboratories but a Keeling-scale concentration must be assigned as that is the accepted international scale. The inter-laboratory intercomparison results indicated that AES and NOAA/GMCC were in very good agreement. As a result of this good agreement, the West German Environmental Agency has asked our laboratory to assign a Keeling/S10 scale value to their NBS standards and to advise them on upgrading their own CO_2 calibration system.

After the NBS meeting, Dr. Graeme Pearman of CSIRO Australia visited the Alert station. Dr. Pearman was instrumental in establishing the Cape Grim baseline monitoring station and the Australian CO_2 program.

Contact: N.B.A. Trivett

3.6.2 International Symposium in Canada

Canada hosted the very successful Sixth International Symposium of the Commission for Atmospheric Chemistry and Global Pollution at Trent University in Peterborough, Ontario during August 1987.

Contacts: D.M. Whelpdale, S. Melnichuk

3.6.3 Centre for Atmospheric Research Experiments (CARE)

In support of the Air Quality Strategic Plan initiative to develop regional integrated research monitoring facilities, CARE at Egbert, Ontario, was started in 1987 as a centre for atmospheric research. Replacing and augmenting the work done previously at the Woodbridge Station for Atmospheric Experiments, CARE will be a multi-disciplinary facility which can support both AES's research effort and also cooperative programs with the Province, universities and industry. Initially, CARE will consist of a CAPMoN station, a reference climate station, a reference solar radiation facility, a climate research station, an atmospheric optics facility and a weather instrumentation remote sensing facility. These efforts involve ARD, CCC, CSD and the Ontario Region.

During 1988, major field studies such as the EMEFS will be conducted at CARE. These projects will measure species important to the acid rain, toxics and climate efforts. Cooperative use of the CARE facility by outside agencies is encouraged.

Contacts: J.W.S. Young, F. Froude, R.M. Hoff

3.6.4 NATO Advanced Research Workshop

AES was a joint sponsor, along with NATO and the Office of Naval Research, in a research workshop to examine the mechanisms of sound generated by the ocean surface. The role that turbulence and bubbles play in such processes is of significance to the exchange of gases and particles at a water-atmosphere interface. The workshop was held June 15-19 in Lerici, Italy. It brought together specialists in geophysical hydrodynamics and acoustics from around the world. Topics included wind and wave sound generative mechanisms, rain and ice noise as well as extensive discussions of breaking waves, turbulence, bubbles and sound propagation.

Contact: B.R. Kerman

3.6.5 Canadian Wetlands Project

A cooperative project was developed between AES and York University to develop ways of sampling for hydrocarbons and halocarbons by using special sampling canisters, and perform analysis by modern gas chromatography techniques. As a first step samples were collected during the summer of 1987 to support two projects mentioned elsewhere in this report: a) samples were collected near Niagara Falls and analyzed for chloroform b) during the period July-August daily flask samples were collected at the Algoma CAPMoN site, and analyzed for CH_4. This study is intended as a feasibility study for the Canadian Wetlands project.

Techniques for analyzing air samples for bromoform and ethylene were developed, supporting the Polar Sunrise Experiment. Furthermore a start was made to develop analysis methods for natural hydrocarbons.

Contacts: J.W. Bottenheim, H. Niki, B. Khouw

3.6.6 Co-ordination - 1987 Great Lakes Water Quality Agreement

During 1987, modifications to the Great Lakes Water Quality Agreement were made and the new agreement was signed in Toledo, Ohio, in October. Under the new agreement, atmospheric processes and their importance as inputs of toxic chemicals to the Great Lakes were recognized. Annex 15 of the Agreement outlines areas of research and monitoring which should be undertaken. This redirection has given added impetus to the AQRB Toxics Chemicals Program and will result in the installation of a Master Research Station at Point Petre, Ontario, in 1988, in cooperation with the National Water Research Institute (NWRI) and the Ontario Ministry of the Environment. In addition, the focus of the toxics program has been narrowed to attack the goals in the research section of the Annex.

Contacts: R.E. Mickle, R.M. Hoff

3.6.7 Formation of the Canadian Institute for Research in Atmospheric Chemistry (CIRAC)

The birth of the Canadian Institute for Research in Atmospheric Chemistry was officially announced on February 7, 1988.

CIRAC was formed in response to growing concern about the rapid increases of emissions of substances into the atmosphere. CIRAC intends to address these vitally important problems with emphasis on those which have particular relevance to Canada. The Institute will also provide training opportunities to meet the world shortage of atmospheric chemists.

The Institute was founded on the existing strengths in the atmospheric sciences at York University, the Atmospheric Environment Service of Canada, the Ontario Ministry of the Environment and Ontario Hydro. It is actively extending this base to include atmospheric scientists in other Canadian universities, government agencies and in industries concerned with problems relating to atmospheric chemistry.

CIRAC is being incorporated as a Canadian, non-profit organization. It will be governed by an independent Board of Directors drawn from the major sectors of government, industry and universities with interests in atmospheric chemistry. The interim board has members from the Atmospheric Environment Service of Environment Canada, Ford Motor Company of Canada, Noranda Inc., Ontario Hydro, Ontario Ministry of the Environment, Texaco Canada Inc., Concord Scientific Corporation and York University.

Harold I. Schiff, University Professor at York University and one of the world's leading atmospheric chemists, is serving as acting Executor Director of CIRAC.

The research activities of the Institute will be project oriented. Team research, particularly research involving scientists from all three sectors - government, university and industry - will be encouraged. A Scientific Steering Committee is responsible for developing the scientific program of CIRAC and for formulating and approving the collaborative research projects.

Contact: J.W.S. Young

4. WEATHER SERVICES REGIONAL AIR QUALITY REPORT

4.1 LONG RANGE TRANSPORT OF AIR POLLUTANTS (LRTAP)

4.1.1 Atlantic Region provided consultation services to New Brunswick on their new acid deposition network in southern New Brunswick.

The Atlantic Region Long Range Transport of Air Pollutants (LRTAP) Monitoring and Effects Working Group workshop was held October 6, 1987 in Bedford, N.S. Eleven oral presentations and one poster presentation were given on a variety of regional "acid rain" research and monitoring projects, as well as six overviews of the national LRTAP programs. Over 45 federal, provincial and university researchers participated.

Contact: B. Beattie

4.1.2 Pacific Region continued the analysis of the precipitation chemistry data collected from the South Coast B.C. network. Don Faulkner presented a report on the analysis at the Pacific Northwest International Section of APCA held in Seattle November 9-10. Arrangements have been made with the UBC Department of Statistics to undertake a more rigorous analysis of the data, specifically to determine the effect of the ASARCO smelter (Tacoma) closure on the rain chemistry of B.C.

As a contribution to the work of the Western and Northern Canada LRTAP Technical Committee, the Region prepared an annotated bibliography of literature related to acidic deposition in western Canada. A limited number of copies are available for distribution.

The installation of the CAPMoN Station on Saturna Island was delayed pending approval of a long-term lease. It is anticipated the station will be completed in 1988.

The Region supported the B.C. Ministry of Environment and Parks monitoring program by operating precipitation samplers at Vancouver, Kelowna and Port Hardy Airports.

Contact: B. Thomson

4.1.3 Ontario Region completed the study of the extreme deposition episodes during 1982 at APN stations in Ontario and published a SSD internal report.

A cooperative SSD/Ontario Ministry of the Environment project to determine and document the meteorological conditions and air trajectories associated with high wet deposition episodes of $SO_4^{=}$, NO_3^{-}, and H^{+} at the CAPMoN and MOE stations in Ontario is underway, with a view to assessing predictability of these events.

Contact: B. Srivastava

4.1.4 Central Region provided the secretary to the Western Canada LRTAP Technical Committee. This committee released and distributed a report on interim target loadings of acidic deposition in Western Canada (copies available from Ron Hopkinson). These loadings were not quantified however, so the committee then established a task group to define the interim target loading values for Western Canada, and develop a strategy for their implementation.

Contact: R. Hopkinson

A paper entitled "The Impact of Atmospheric Transport on the Epidemiology of Influenza Virus Infections" was co-authored by R.L. Raddatz with G.W. Hammond and D.E. Gelsky of the Cadham Provincial Laboratory and University of Manitoba Medical School, and submitted to the medical journal Lancet.

Contact: R. Raddatz

4.1.5 Québec Region opened a new station in Chapais. The daily bulletin on acid precipitation continues. We represented AES at AQPAC (Association québécoise pour la lutte contre les pluies acides) and at the acid rain symposium by the Union of Agricultural Producers.

Our operations continue at the CAPMoN stations of Sutton, Port Cartier and Pennsylvania. At Forêt Montmorency, we negotiated an agreement for a period of five years with Laval University to continue the operations.

Contact: G. Desautels

4.1.6 Western Region maintains active involvement on the Steering Committee looking at research into the role of dust in precipitation chemistry over western and northern Canada.

Computer runs were completed using three statistical LRTAP models (SERTAD, OME and RCDM) and a special database constructed for western Canada.

The CAPMoN station at Esther, Alberta has completed its first year of operation. A CANSAP sampler was operated in parallel at the station for comparison purposes.

Assistance was provided to Alberta Environment in establishing a CAPMoN type sampling station in the Peace River region. This station began operation late in 1987.

Negotiations concluded with GNWT and NCPC to establish a CAPMoN station in the Snare River Rapids area. The station will be installed during the summer of 1988 and will be funded by GNWT, being operated by NCPC.

Contact: B. Hume

4.2 TOXIC CHEMICALS

4.2.1 Ontario Region arranged and facilitated initial discussions between the Atmospheric Research Directorate and Canadian Coast Guard, Parry Sound to establish a field site on one of the Western Islands for the study "Re-suspension of Toxic Substances in a Breaking Wave Regime Over the Great Lakes".

Contacts: P. Chen, L.A. Barrie

4.2.2 Atlantic Region provided consultation to Conservation and Protection on meteorological aspects of emission impacts of residential combustion heating systems (wood stoves).

Contact: B. Beattie

4.2.3 Central Region managed a study contracted with the Saskatchewan Research Council, with PESTFUND support, in which PS-1 PUF samplers were deployed in Saskatchewan at Cree Lake (background control site) and Rock Point (agricultural area) to monitor pesticide vapours in the atmosphere. Samples were collected for the months from June to October inclusive, based on daily operation between noon and 2:00 p.m. During that time of the day the lower atmosphere is generally well mixed. No pesticides were confirmed above the detection limits of the monitoring system. The report is available from Garry Schaefer.

Lectures were provided to three pesticide applicator licencing courses in Manitoba on dispersion and weather.

Presentations were made to hearings of the Manitoba Clean Environment Commission on smoke dispersion and water.

Contact: B. Atkinson

4.3 OXIDANTS

4.3.1 Atlantic Region participated in the initial meeting of the newly-formed inter-governmental group to exchange scientific and technical information on oxidants in the Atlantic provinces and Maine. AES prepared a list of stations measuring ozone in the Atlantic provinces.

The Region assisted Conservation and Protection in producing a study on oxidants in Nova Scotia and New Brunswick (done under contract).

Contact: B. Beattie

4.3.2 Québec Region participated at meetings of the inter-governmental group on oxidants. We were also active in radio and television interviews during the international ozone conference in Montréal in September.

Contact: G. Desautels

4.4 ENVIRONMENTAL EMERGENCY RESPONSE PROGRAM (EERP)

4.4.1 Atlantic Region prepared and issued a contract to develop training modules for Emergency Response Scenarios. The Maritimes Weather Centre prepared a manual to assist the forecasters in running AQPAC and SLICK.

Atlantic Region was requested to run SLICK on 3 occasions by EPS, once for an oil spill which occurred in the harbour at St. Pierre, France, and twice to try and locate the source of oil which killed large numbers of sea birds.

We are preparing the AES input to the EC Communications Plan for the Nova Scotia Regional Emergencies Telecommunication Committee. As well, AES input to "Federal Peacetime Emergency Procedures - New Brunswick", and "Canada Newfoundland Offshore Petroleum Board Emergency Response Plan" was reviewed and updated.

Contacts: R. Nelis, J. Bursey, B. Beattie

4.4.2 Pacific Region sponsored and hosted a one-day workshop on AES EER capabilities on October 21, 1987. About 40 municipal, provincial and federal emergency response agency personnel attended.

Pacific Region initiated a contract to (a) survey the AES needs for a meso-scale wind model and (b) survey existing models which would be useful for environmental emergency response.

Scientific Services, the Pacific Weather Centre and the Kamloops Weather Office participated in two simulated emergency exercises involving leaks of toxic hazardous gases.

A climatological analysis of trajectories of air parcels from the nuclear reactor at Hanford, Washington was completed.

Contacts: F. Herfst, B. Thomson

4.4.3 Ontario Region, through the Sarnia Weather Office, presented a summary of climatic conditions important to air pollution in the Sarnia area at an industry sponsored workshop on environmental emergency preparedness.

AQPAC version 3 was implemented and contact lists were updated. Ontario Weather Centre shift supervisors and senior meteorologists were trained. Demonstrations provided to C&P and the Canadian Coast Guard personnel.

The Regional Contingency Plan was updated and distributed. Input was provided to C&P on the Ontario Region, Regional Departmental Plan.

Participated on Canada-U.S. Coast Guard CANUSLAK Exercise on the scenario development and delivery team; Ontario Weather Centre provided dispersion modelling support to the Joint Response Team during the exercise.

Provided various regional input to ARQD EER Program initiatives and reviews. Regional input formalized via membership on the AES-EER Advisory Group.

Regional input and support were provided in the presentation of the Departmental Brief to the Ontario Nuclear Safety Review.

Contacts: P. Chen, B. Srivastava

4.4.4 Central Region undertook a project to convert the existing AQPAC package of programs for emergency response to the new RSERP computer, and continued to make the models more user-friendly, bullet-proof and bilingual. The trajectory program was modified to output to the HP7580 pen plotter.

There were three chemical environmental emergencies in the Region in which AES was contacted by an outside agency. One was in the vicinity of Emerson, Manitoba where a tank car carrying butane derailed but did not leak. However, an area of the town was evacuated. Another was a perceived spill of a pesticide from a tanker truck in Regina. However at the temperatures that existed that day the chemical is more like a solid than a liquid, and did not flow or vapourize. The last was a spill of anhydrous ammonia from a tanker truck in Regina which required the evacuation of a small area of the city.

Information on chemical environmental emergencies in the Region over the past few years was provided to Oceanroutes Canada Inc.

Contacts: B. Atkinson, R. Hopkinson

4.4.5 Québec Region continued to develop tools to respond to emergencies. We also participated in the provincial emergency exercise called JOSERP-1987.

Contact: G. Desautels

4.4.6 AQPAC models continue to be evaluated and upgraded in consultation with Central Region (CAESE). Training to operational staff on the use of models has been enhanced by the installation of the software package on the operational systems.

The Yukon Weather Centre has been actively involved in Emergency Response planning with private industry providing output from AQPAC to a company in Faro, Y.T.

The Severe Weather Team, Alberta Weather Centre, and Scientific Services Division assisted other federal agencies, provincial and Edmonton City groups during the aftermath of the July 31, 1987 Tornado.

Contact: B. Hume

4.5 ENVIRONMENTAL ASSESSMENT AND REVIEW PROCESS (EARP)

4.5.1 Ontario Region, in the assessment of the local dispersion climatology at Port Hope, has completed the final draft of "A Comparison of Modelled Long-Term Air Concentrations at Port Hope Using Remote and Local Meteorological Data, and Using the Original and Modified Versions of the Climatological Dispersion Model". This report is co-authored SSD with ARQM. Report on the detailed analysis of the Port Hope field data (1984-86) is being written.

Contact: P. Chen

4.5.2 Central Region participated in the reviews of the Shand Generating Station EIS, Rafferty and Alameda Dams EIS, Cigar Lake Uranium development EIS, and the Collins Bay A, B, and Eagle Point Uranium mine EIS. The chair of the Regional Screening and Co-ordinating Committee (RSCC) Mining South of 60 sub-committee was provided by Central Region.

Contacts: R. Hopkinson, B. Atkinson

4.5.3 Atlantic Region participated in and coordinated the AES review of the following documents for the proposed NB-PEI fixed link:

- Social Impact
- Fishery and Environment
- Ice
- Soil and Erosion
- Winds, Waves, Tides and Currents
- Vessel Traffic and Bridge Safety
- Tunnel Feasibility
- Bridge Substructure Design (Foundation)
- Bridge Superstructure Design (Frame)
- Economic and Financial Assessment
- Risk Scoping Matrices (4) for Tunnel and Bridge dealing with Marine Biophysical and Socio-Economic concerns
- Draft IEE for the Fixed Link
- DOE draft position statement on the Draft IEE for the NB-PEI Fixed Link

Atlantic Region reviewed the following: A DFO Science discussion paper entitled "An Assessment of the Possible Environmental Impacts of Exploratory Drilling on Georges Bank Fishery Resource"; DOE white paper on Environmental Assessment Legislation; documents relating to the North Warning System & Petro Canada's Emergency Response plans; documents dealing with Pt. Lepreau II and Coleson Cove; North Core Emergency Response plan for the East Coast; DOE Discussion paper entitled "Reforming Federal Environmental Assessment".

Contacts: J. Bursey, S. Porter

4.5.4 Western Region participated in the review of the PMF for the Old Man River Dam project, responded to RERC on the Gulf Canada Amauligak Project proposal, and reviewed the EIS on SACV low level flights.

Western Region had discussions with MOT as well as consultants over the impacts of wood fired boilers at the Fort Smith airport. Wood smoke monitoring programs in Whitehorse were also reviewed with C&P through the Yukon Weather Centre.

Contact: B. Hume

4.5.5 Québec Region participated in a training course on Federal procedures for environmental assessment.

Contact: G. Desautels

5. PUBLICATIONS

5.1 JOURNAL PUBLICATIONS

Barrie, L., G. denHartog, J. Bottenheim, and S. Landsberger. Aerosols and gases in the lower troposphere at Alert, Canada in April, 1986. Submitted to J. Atmos. Chemistry.

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Beljaars, A. C. M., J. L. Walmsley and P. A. Taylor, 1987: A Mixed Spectral Finite-Difference Model for Neutrally Stratified Boundary-Layer Flow Over Roughness Changes and Topography. Boundary-Layer Meteorol., 38, 273-303.

Beljaars, A. C. M., J. L. Walmsley and P. A. Taylor, 1987: Modelling of Turbulence Over Low Hills and Varying Surface Roughness. Boundary-Layer Meteorol., 41, 203-215.

Bottenheim, J.W. and A.J. Gallant, "The occurrence of PAN over the Atlantic Ocean east of North America during WATOX 86", submitted to Global Biochemical Cycles, April.

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Daum, P., T. Kelly, W. Strapp, R. Leaitch, P. Joe, R. Schemenauer, G. Isaac, K. Anlauf, and A. Wiebe: "Chemistry and Physics of a Winter Stratus Cloud Layer: A Case Study" J. Geophysical Research, 92, 8426-8436 (1987).

Galloway, J.N. and D.M. Whelpdale, 1988: "WATOX-86 overview and western North Atlantic S and N atmospheric budgets". Atmos. Environ. (accepted for publication).

Higuchi, K., N.B.A. Trivett and S.M. Daggupaty, 1987: A preliminary climatology of trajectories related to atmospheric CO_2 measurements at Alert and Mould Bay. Atmos. Environ., 21, 1915-1926.

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Hoff, R.M., Vertical Structure of Arctic Haze Observed by Lidar, J. Appl. Met. 27, 125-139, 1988.

Hopper, J.F and L. Barrie, 1988,Regional and background aerosol trace elemental composition observed in eastern Canada, Tellus, 40B, in press.

Padro, J., A Procedure for Computing Vertical Profiles of Wind in the Planetary Boundary Layer. Submitted to Atmospheric Environment.

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Schroeder, W.H., D.A. Lane: "The Fate of Toxic Airborne Pollutants", Environ. Sci. Technol., 22,(3) 240-246, 1988.

Schroeder, W.H. and F.H. Fanaki, 1988 "Field Measurements of Water-Air Exchange of Mercury in Freshwater Systems". Accepted for publication in Environmental Technology Letters.

Sirois, A. and L.A. Barrie, 1988: "An estimate of the importance of dry deposition as a pathway of acidic substances from the atmosphere to the biosphere in eastern Canada", Tellus, 40B, 59-80.

Strapp, J.W., W.R. Leaitch, K.G. Anlauf, J.W. Bottenheim, P. Joe, R.S. Schemenauer, H.A. Wiebe, G.A. Isaac, T.J. Kelly and P.H. Daum "Winter cloudwater and air composition in central Ontario", submitted to J. Geophys. Res., August.

Sturges, W.T. and L.A. Barrie, 1988: Chlorine, bromine and iodine in Arctic aerosols, Atmos. Envir., 22 in press

Sturges, W.T. and L.A. Barrie, 1987: Laed 206/207 isotope ratios in the atmosphere of North America as tracers of US and Canadian emissions, Nature, 329, 144-146.

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Whelpdale, D.M., W.C Keene, A.D.A. Hansen and J. Boatman, 1988: "Aircraft measurements of sulfur, nitrogen and carbon species during WATOX-86". Global Biogeochemical Cycles (accepted for publication).

5.2 INTERNAL REPORTS

Clark, T.L., R.L. Dennis, E.C. Voldner, M.P. Olson, S.K. Seilkop, M. Alvo: International Sulfur Deposition Model Evaluation, EPA/600/3-87/008, ARD-87-1, AES, Downsview, Ontario, May 1987 (released March 1988).

Hoff, R.M., J. Bottenheim, H. Niki, P. Forsyth, B. Khouw, S. Barnett, and P. Fellin: Vapour Phase Air Concentrations of PCBs and Chloroform at Niagara Falls, ARD-87-4, Atmospheric Environment Service (ARDS), 4905 Dufferin Street, Downsview, Ontario, October 1987.

Vet, J.R., W.B. Sukloff, M.E. Still, J.B. Martin, W.F. Kobelka and A. Gaudenzi: Canadian Air and Precipitation Monitoring Network (CAPMoN) Precipitation Chemistry Data Summary 1985. AQRB-88-01, January 1988.

Vet, J.R., W.B. Sukloff, M.E. Still, J.B. Martin, W.F. Kobelka and A. Gaudenzi: Canadian Air and Precipitation Monitoring Network (CAPMoN) Precipitation Chemistry Data Summary 1986. AQRB-88-02, March 1988.

6. MAJOR CONTRACTS ($4,000 and over)

Bermuda Biological Station $ 4,600	To prepare aerosol sampling collection and analysis on Bermuda
Concord Scientific $ 15,000	To recalibrate carbon dioxide/methane gas chromatograph and install same at Alert
Concord Scientific $ 19,000	To enhance the COBRA III Hazard Assessment Model
Concord Scientific $ 11,200	To unload/load filter packs for AES air sampling network
Concord Scientific $ 14,500	To evaluate and analyze data on peroxy-acetyl nitrate (PAN)
Galer & McMillan Communications Inc. $ 5,600	To illustrate architectural rendering of CARE site
Institute of Environmental Studies, University of Toronto $ 16,000	To biologically monitor for airborne organic and metal contaminants in Upper Lakes Basin
Institute of Environmental Studies, University of Toronto $ 4,000	To support AES on project biogeochemical cycling
Mann Testing Lab $ 7,500	To provide analysis of polychlorinated biphenyls in atmospheric samples
Mathews, Tom $ 16,100	To develop and implement the National Atmospheric Chemistry Data Base System
MEP Company $ 34,600	To generate high resolution analysis of meteorological fields
MEP Company $ 70,400	To prepare meteorological input fields (in the form developed for ADOM model) for selected set of episodes
MEP Company $ 51,300	To generate meteorological fields for OSCAR experiment using Kuo Cloud version of spectral model
MEP Company $ 22,300	To provide technical services for the continuation and maintenance of the Data Management System for model data archiving

Ontario Research Foundation $115,000	To assist AES scientists in the conduct of field measurements and laboratory based investigations using GAP sampler.
RSD Graphics $ 21,000	To evaluate and write position descriptions for Branch re-organization
Salmon, Dr. J.R. $ 10,000	To develop and evaluate the Portable Weather Stations for deployment in Environmental Emergency situations
Salmon, Dr. J.R. $ 10,000	To research possible alternate to MS-MICRO
Salmon, Dr. J.R. $ 7,800	To analyze and interpret CASP '86 surface mesonet data
Salmon, Dr. J.R. $ 8,500	To install a small mesonet of surface weather stations in the vicinity of the Pickering Nuclear Generating Station
SCS Consultants $ 34,300	To investigate variability in concentration and deposition patterns.
Skeleton Technical Services Inc. $ 55,500	To quality control data from CAPMoN Network
Sophos Inc. $ 5,500	To participate in workshop on Emission Reduction Scenarios to reduce photochemical smog
University of Guelph $ 25,000	To determine the CO2 exchange between atmosphere and a large agricultural crop area
University of New Brunswick $ 27,000	To produce an optimum spray combination and operating strategy to ensure minimum off-target drift
Unisearch Assoc. $ 18,100	To test AES tuneable diode laser system for inlet line effect

7. UNSOLICITED PROPOSALS

Nil

8. SCIENCE SUBVENTIONS 1987-88

APPLICANT/ INSTITUTION	SCIENTIFIC AUTHORITY	TITLE
Bunce, N.J. University of Guelph $ 8,000.00	D. Lane	Estimation of solar assisted decomposition of chlorophenols
Chakrabarti, C.L. Carleton University $10,000.00	K. Puckett	Total analytical system to determine metal content in particles
Hastie, D.R. York University $ 8,000.00	D.M. Whelpdale	WATOX data interpretation
Lee-Ruff York University $11,000.00	D. Lane	Investigations of environmental transformation of PAH
Moore, R.M. Dalhousie University $ 6,000.00	K. Higuchi	Surface water CO2 values in Beaufort Sea
Moore, T.R. McGill University $ 8,000.00	M. Phillips	CH4 and CO2 evaluation from peatlands in Eastern Canada
Ormrod, D.P. University of Guelph $10,000.00	M. Phillips	Effects of dynamic air pollutant combinations on plants
Picot, J.J.C. Univ. of New Brunswick $10,000.00	R. Mickle	Simulation of deposition and drift from aerial spraying
Snieckus, V. University of Waterloo $10,000.00	D. Lane	Simulated atmospheric chemistry of methyl-PAH's and nitro-PAH's
Stubley, G.D. University of Waterloo $10,000.00	P. Taylor	Boundary layer modelling with high order closure models
Thurtell, G. University of Guelph $12,000.00	G. den Hartog	Measuring and modelling dry deposition and pollution flux to forests

April, 1988

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	Dr. J. Bottenheim	4838	4S110
	A. Gallant	4874	4S650
	S. McNair	4450	4S844
	D. MacTavish	4847	4S131
*	T. Adamson	4848	4S131
	Dr. S. Ahmed	4845	4S132
	W. Kobelka	4461	4S670
	A. Gaudenzi	4459	4S640B
	B. Martin	4458	4S640B
	B. Vet	4457	4S620
	B. Sukloff	4456	4S620
	C. Ro	4455	4S831
**	Dr. N. Trivett	4447	4S830
	Dr. K. Higuchi	4452	4S841
	Dr. S. Daggupaty	4451	4S843
	S. Iqbal	4683	1S561
*	D. Worthy	4462	1S561
*	D. Symington	4462	1S561
	CO_2 Lab	4462	1S561
PDF	Dr. F. Akeredolu	4463	3S690A

* Denotes term or assignment
** Development Leave

10. ACKNOWLEDGEMENTS

I hope that this report will serve the readers as a source of information about our scientific activities. Readers are welcomed to approach the listed contacts for more detailed information. In particular, copies of our scientific publications can be requested from the individual scientists.

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Jacob Padro